FINAL DRAFT REPORT

Water Supply Study

James City Service Authority

Date: April 2015

CONFIDENTIAL

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April 24, 2015

Mr. Michael Vergakis, P.E.
Chief Engineer - Water
James City Service Authority
Engineering
119 Tewning Road
Williamsburg, Virginia 23188-2639

Subject: Water Supply Study – Final Draft Report

Dear Mr. Vergakis:

Enclosed are five copies of the Water Supply Study, Final Draft Report. Comments received from you and your staff on the Revised Draft Report dated February 2015 have been incorporated into this report.

This report evaluates the feasibility of potential water supply sources bordering James City County and the impact of purchasing drinking water from Newport News Waterworks under your current agreement. Based on current permitting conditions and without purchasing water from Newport News Waterworks, it appears that water demands will exceed available permitted capacity by 2020. If JCSA's groundwater withdrawal permit is reduced, the deficit could be immediate.

Thank you for the opportunity to be of service to the James City Service Authority. We look forward to assisting the James City Service Authority in further evaluation of the feasible water supply alternatives. Please contact us if you have any questions.

Very truly yours,

Philip M. Hecht

Philip M. Hecht, P.E., BCEE
Senior Project Manager
CDM Smith Inc.

Enclosure

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Acronyms

B	booster stain
cfs	cubic feet per second
cfu	colony-forming units
Cl_2	Chlorine
DBP	Disinfection Byproduct Rule
DCR	Virginia Department of Conservation and Recreation
deg C	degrees Celsius
DEQ	Virginia Department of Environmental Quality
EDR	Electrodialysis reversal
EIS	Environmental Impact Statement
EPA	U. S. Environmental Protection Agency
ES	elevated storage
EVGMA	Eastern Virginia Groundwater Management Area
FBRR	Filter Backwash Recycling Rule
FFWTF	Five Forks Water Treatment Facility
FY	fiscal year
g/L	grams per liter
gpcd	gallons per capita per day
gpm	gallons per minute
GWR	Groundwater Rule
HAA5	Haloacetic Acids 5
hp	horsepower
HRRWSP	Hampton Roads Regional Water Supply Plan
JCSA	James City Service Authority
JPA	Joint Permit Application
kW	kilowatt
LAA	Location Annual Average
LCR	Lead and Copper Rule
LT2	Long Term 2 Enhanced Surface Water Treatment Rule
mgd	million gallons per day
mg/L	milligrams per liter
MIF	minimum instream flow
N	Nitrogen
NNWW	Newport News Waterworks
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
PDA	Project Development Agreement

ppt	parts per thousand
PRV	pressure reducing valve
PSA	Primary Service Area
RAA	Running Annual Average
RO	Reverse Osmosis
rpm	revolutions per minute
RRWSG	Raw Water Regional Water Supply Group
SCADA	supervisory control and data acquisition
TCR	Total Coliform Rule
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
TTHM	Total trihalomethane
USACE	U. S. Army Corps of Engineers
uS/cm	microsiemens per centimeter
USGS	United States Geological Survey
VAC	Virginia Administrative Code
VAW	Virginia American Water
VDGIF	Virginia Department of Game and Inland Fisheries
VDH	Virginia Department of Health
VDOT	Virginia Department of Transportation
VECOS	Virginia Estuarine and Coastal Observing System
VMRC	Virginia Marine Resources Commission
VPDES	Virginia Pollution Discharge Elimination System
VSMP	Virginia Stormwater Management Program
VT	Virginia Tech
VWP	Virginia Water Protection Permit
W	Well
WTP	Water Treatment Plant

Section 1

Introduction

James City Service Authority (JCSA) is the largest public water system in Virginia that relies solely on groundwater as its primary water supply source.[1] JCSA's reliability of long-term dependence on exclusive use of groundwater is uncertain due to tighter regulatory restriction on groundwater by the Virginia Department of Environmental Quality (DEQ). DEQ regulates and permits groundwater withdrawals in the Eastern Virginia Groundwater Management Area (EVGMA) and proposes to reduce the amount of groundwater that JCSA and other permitted users are permitted to withdraw due to declining groundwater levels, advancing saltwater intrusion, and land subsidence in the EVGMA. A reduction in the permitted groundwater withdrawal will have a significant impact on JCSA's ability to provide adequate water supply to meet their existing and future water demand needs.

JCSA contracted CDM Smith to identify potential water supply options available to meet their projected water demands. The scope of work of the water supply study presented in this report consists of the following tasks:

- Determine water supply needs based on available projections.
- Review the existing groundwater permit and determine potential impacts if withdrawal is reduced.
- Review the Newport News Waterworks (NNWW) water purchase agreement and determine potential impacts for long-term purchase.
- Describe the Ware Creek Reservoir option and state the reasons why the project was abandoned.
- Describe the King William Reservoir option and state the reasons why the project was abandoned.
- Evaluate the York River as a potential water supply source.
- Evaluate the Chickahominy River as a potential water supply source.
- Evaluate the James River as a potential water supply source.
- Evaluate the feasibility of expanding the existing Five Forks water treatment facility by 20 percent.
- Provide a matrix of viable water supply options including the pros and cons for each option.

The analysis of each water supply alternative includes identification of treatment options, permit requirements/obstacles, probability of success, and financial impacts. Hydraulic modeling, safe yield

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[1] http://www.jamescitycountyva.gov/bewatersmart/rebateprograms/rebatesintroduction.html (Last accessed February 10, 2015)

analyses, water quality sampling, and other field work are not included in the scope of work of this study. A water rate study is not included in the scope of work; however, planning-level cost estimates are provided for JCSA's development of potential water rates.

To present the results of the water supply study, the remainder of the report is divided into the following sections:

- Section 2 Existing DEQ Groundwater and VDH Waterworks Operation Permits
- Section 3 Water Supply Needs
- Section 4 Newport News Waterworks Water Purchase Agreement
- Section 5 Ware Creek Reservoir
- Section 6 King William Reservoir
- Section 7 York River
- Section 8 James River
- Section 9 Chickahominy River
- Section 10 Groundwater Sources
- Section 11 Permit and Approval Requirements
- Section 12 Evaluation Results of Potential Alternatives

Section 2

Existing DEQ Groundwater and VDH Waterworks Operation Permits

JCSA is authorized to provide potable water to the public through the DEQ Groundwater Withdrawal Permit and the Virginia Department of Health (VDH) Waterworks Operation Permit. The DEQ Groundwater Withdrawal Permit establishes the quantity of groundwater that JCSA is allowed to withdraw as an annual total withdrawal in gallons and as a total maximum monthly withdrawal in gallons. The VDH Waterworks Operation Permit regulates the capacity in gallons per day of the JCSA water system. A discussion of each permit and DEQ's groundwater withdrawal policy status follows.

2.1 DEQ Groundwater Withdrawal Permit

James City County is located in the Eastern Virginia Groundwater Management Area (EVGMA) as defined by the Virginia Administrative Code (9VAC25-600-20). The EVGMA was established in 1992 due to declining water levels in the aquifers. JCSA was permitted by VDH as a public water supplier prior to the establishment of the EVGMA. Regulations imposed on the EVGMA are intended to protect existing users from new or expanded withdrawals, assure continued resource viability into the future, and manage the resource comprehensively. A groundwater permit is required by DEQ for any withdrawal in the EVGMA greater than 300,000 gallons per month.

JCSA provides water service to their customers through the Central Water System and eight independent water systems. The Central Water System and independent water systems have separate DEQ Groundwater Withdrawal Permits as described below.

2.1.1 Central Water System

This study focuses on the Central Water System which serves the Primary Service Area (PSA), Governor's Land, Greensprings West, and three public schools. The following milestones describe JCSA's DEQ Groundwater Withdrawal Permit history for the Central Water System:

- **Permit effective July 1, 1998, expiration June 30, 2008 -** JCSA was first permitted by DEQ to withdraw in the EVGMA for the Central Water System an annual total of 1,742,900,000 gallons which is an average of 4.8 million gallons per day (mgd) (maximum gallons per year divided by 365 days) and a monthly total of 206,675,000 gallons during the maximum month which is an average of 6.7 mgd (maximum gallons per month divided by 31 days).

- **Permit with additional wells under construction for Five Forks Water Treatment Facility (FFWTF), effective January 1, 2003, expiration December 31, 2012 -** JCSA was later permitted by DEQ to withdraw up to an annual total of 3,267,000,000 gallons (8.95 mgd) and up to a maximum monthly total of 374,558,000 gallons (12.1 mgd). This permit included the wells for FFWTF as proposed for construction.

- **Modified Permit for converting FFWTF wells under construction to permanent wells, effective January 1, 2003, expiration December 31, 2012 -** A modified permit was issued by DEQ to JCSA on January 3, 2005 for conversion of the wells proposed for construction at the

FFWTF to permanent wells. The modified permit retained the effective date of January 1, 2003 and the expiration date of December 31, 2012 and allowed JCSA to withdraw up to an annual total of 3,267,000,000 gallons (8.95 mgd) and a monthly total of 374,558,000 gallons (12.1 mgd).

- **Modified Permit for combining Stonehouse independent water system with Central Water System, effective January 1, 2003, expiration December 31, 2012 -** A modified permit was issued by DEQ to JCSA on August 17, 2009 to merge the Stonehouse independent water system with the Central Water System. This modification retained the permit's effective date of January 1, 2003 and the expiration date of December 31, 2012. To include the Stonehouse water system in the permit, DEQ required that the 1-foot drawdown contour of the current Central Water System permit not be exceeded. The withdrawal allocations for each well had to be evaluated and withdrawal allocations redistributed. As a result, JCSA's permitted withdrawal was reduced from the combined previously permitted annual withdrawal amount of the Stonehouse independent water system and the Central Water System of 3,529,800,000 gallons (9.67 mgd) to 3,222,269,520 gallons (8.83 mgd) and the combined monthly withdrawal amount of 408,038,000 gallons (13.16 mgd) to 364,798,000 gallons per month (11.8 mgd). Thus, the total reduction of the previously DEQ permitted withdrawals was 307,530,480 gallons per year (0.84 mgd) and 43,240,000 gallons per month (1.4 mgd).

- **Permit Renewal Application submitted April 5, 2012 -** In accordance with Virginia regulations (9VAC25-610-96), JCSA was required to submit a reapplication permit at least 270 days before the expiration date unless permission for a later date had been granted by the State Water Control Board. JCSA submitted a groundwater renewal permit for an annual average withdrawal of 8.4 mgd and a maximum monthly withdrawal of 11.89 mgd on April 5, 2012, within the stipulated time frame. DEQ has not issued a new permit; however, the existing expired permit is still effective. As stated in 9VAC25-610-96, "If a complete application for a new permit has been filed in a timely manner, and the board is unable, through no fault of the permittee, to issue a new permit before the expiration date of the previous permit, the permit may be administratively continued."

- **DEQ Permit Renewal Application Review Meeting -** On July 15, 2014, DEQ informed JCSA at a meeting that the 8.4 mgd requested did not meet the technical review criteria based on the new DEQ groundwater model results and would not be approved and that a target reduced permit withdrawal of 3.8 to 4.0 mgd was preferred but subject to negotiations with DEQ.

The impact of DEQ's proposed reduction in the Groundwater Withdrawal Permit on the water supply needs of the Central Water System is discussed in Section 3.

2.1.2 Independent Water Systems

The independent water systems are separate water systems owned and operated by JCSA, each with their own unique well. The independent water systems include:

- Wexford Hills and Riverview Plantation Subdivision
- Racefield Subdivision
- Glenwood Acres Subdivision

- Kings Village Subdivision
- Ware Creek Manor Subdivision
- The Retreat Subdivision
- Liberty Ridge Subdivision
- Westport Subdivision

Wexford Hills and Riverview Plantation, Racefield, Kings Village, Ware Creek Manor, and The Retreat independent water systems each has its own DEQ Groundwater Withdrawal Permit. Glenwood Acres water system does not require a DEQ Groundwater Withdrawal Permit because it withdraws less than 300,000 gallons per month.

JCSA has accepted operation of the Liberty Ridge and Westport independent water systems. VDH has not issued an Operation Permit for either system because each system serves less than 15 connections at this time. In addition, the DEQ withdrawal permit for each system is currently a draft permit in each developer's name, pending the issuance of the VDH Operation Permit, and withdrawals reaching 300,000 gallon per month.

2.2 VDH Waterworks Operation Permit

The treatment and distribution of groundwater as potable water is regulated by the VDH Waterworks Operation Permit. VAC 62.1-264 states:

> *To ensure that any ground water withdrawal permit issued for a public water supply does not impact a waterworks operation permit issued pursuant to § 32.1-172, the maximum permitted daily withdrawal shall be set by the Board at a level consistent with the requirements and conditions contained in the waterworks operation permit. This section shall not limit the authority of the Board to reduce or eliminate ground water withdrawals by a waterworks if necessary to protect human health or the environment.*

VDH calculates the operating design capacity based on the limiting water system component, i.e. the lesser of well yield, well pump capacity, booster pump capacity, storage volume, and treatment capacity. The Waterworks Operation Permit may be amended for changes in treatment processes, special operating conditions, and change in capacity.[1]

JCSA has separate VDH Waterworks Operation Permits for the Central Water System and the following independent water systems: Wexford Hills and Riverview Plantation, Racefield, Kings Village, Ware Creek Manor, The Retreat, and Glenwood Acres. Liberty Ridge and Westport are not required to have VDH Waterworks Operation Permits because they serve less than 15 connections at this time.

The Waterworks Operation Permit for JCSA issued by VDH on February 17, 2012 established an operating capacity of 9.973 mgd for the JCSA Central Water System. The Waterworks Operation Permit does not have an expiration date. The capacity in the Waterworks Operation Permit is calculated based on the limiting factor of bulk water storage capacity, booster pump capacities, and source water capacities. For JCSA's Central Water System, the limiting factor is source water. A

[1] http://www.vdh.state.va.us/ODW/PermitandDesign.htm (Last accessed February 10, 2015)

reduction in the DEQ permitted groundwater withdrawal will reduce the permitted capacity in the Waterworks Operation Permit.

This study focuses on the Central Water System. A description of the water operation facilities of the Central Water System follows.

2.2.1 Production and Treatment Facilities

The Central Water System is supplied by 19 wells that draw water from the Potomac and Chickahominy Piney Point aquifers. Five wells are located at the FFWTF and 14 wells supply water at 7 locations. Table 2-1 provides a summary of the annual withdrawal and VDH permitted capacity for the production facilities in the Central Water System. The VDH permitted capacity is affected by the DEQ permitted groundwater withdrawal, but does not correlate one-to-one with the DEQ Groundwater Withdrawal Permit. The permitted withdrawal in the DEQ Groundwater Withdrawal Permit focuses on the raw water supply which includes the brine concentrate in the treatment process while the VDH permitted capacity limits the quantity of finished water that can be fed into the distribution system.

Table 2-1 JCSA Water Production Facilities

Production Facility	DEQ Annual Withdrawal (mgd)	VDH Capacity (mgd) *	Treatment
Five Forks	5.964	5.0	Reverse osmosis, sodium hydroxide for pH adjustment, corrosion inhibitor, sodium hypochlorite for disinfection
Owens-Illinois (W-01)	0.320	0.972	Blending, sodium hypochlorite for disinfection
Stonehouse (W-25 and W-26)	0.670	0.965	Blending, sodium hypochlorite for disinfection
Ford's Colony (W-33)	0.236	0.170	Sodium hypochlorite for disinfection
Kristiansands (W-24 and W-38)	0.861	1.610	Blending, sodium hypochlorite for disinfection
The Pottery (W-4)	0.005	0.360	Sodium hypochlorite for disinfection
Canterbury Hills (W-22)	0.120	0.294	Sodium hypochlorite for disinfection
Ewell Hall (W-5) and Olde Towne Road (W-6)	0.225	0.602	Sodium hypochlorite for disinfection
TOTAL	**8.401**	**9.973**	

*As specified in VDH Waterworks Operation Permit

The FFWTF has a treatment capacity of 5 mgd and uses reverse osmosis to treat brackish groundwater from the Potomac aquifer; approximately 20 percent of the Lower Potomac aquifer water is rejected as brine concentrate in the treatment process. Water from the Middle Potomac aquifer is blended with the permeate water. The brine concentrate is discharged into the James River and regulated by DEQ through a Virginia Pollution Discharge Elimination System (VPDES) Permit. JCSA is required to monitor the following parameters in the concentrate discharge: pH, dissolved oxygen, total dissolved solids, total nitrogen, total phosphorus, nitrate, nitrite, and ammonia. The FFWTF also provides application of sodium hydroxide for pH adjustment, corrosion inhibitor, and sodium hypochlorite for disinfection.

The Owens-Illinois, Stonehouse, and Kristiansands production facilities blend higher quality water from the Chickahominy Piney Point aquifer with lower quality water from the Potomac aquifer. Sodium hypochlorite is added to the water for disinfection prior to distribution.

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The Ford's Colony, The Pottery, Canterbury Hills, Ewell Hall and Olde Towne Road production facilities draw water from the Chickahominy Piney Point aquifer, apply sodium hypochlorite for disinfection, and pump the water directly into the distribution system.

2.2.2 Distribution Facilities

2.2.2.1 Stonehouse Commerce Park (ES-01)

JCSA owns and operates a 1.25-million-gallon elevated storage tank at Stonehouse Commerce Park. The tank is equipped with an altitude valve and has an operating range of 44.5 feet. The overflow is set at elevation 255 feet.

2.2.2.2 Warhill Sports Complex (ES-02)

JCSA also owns and operates a 1.25-million-gallon elevated storage tank at the Warhill Sports Complex. The tank is equipped with an altitude valve and has an operating range of 44.5 feet. The overflow is set at elevation 255 feet.

2.2.2.3 Ironbound Road Booster Facility (BS-27)

The Ironbound Road Booster Facility is located near the intersection of Monticello Avenue and Ironbound Road, east of Route 199. The Ironbound Road Booster Facility consists of two, 500,000-gallon storage tanks and a booster pump station. The booster pump station is equipped with three, 125-horsepower (hp) pumps, each rated 1,936 gallons per minute (gpm) at 166 feet total dynamic head (TDH) based on a speed of 1,750 revolutions per minute (rpm). The tanks normally operate in series, but can also operate individually when one tank is offline. The facility is equipped with a 400 kilowatt (kW) standby generator. This facility normally operates to move water from the FFWTF to northward and westward through the County. The facility can also be operated as a peaking facility where the tanks are filled during off-peak hours and allowed to pump out during peak demands.

2.2.2.4 Route 199 Booster Facility (BS-32)

The Route 199 Booster Facility is located off Route 199, approximately 1,500 feet west of Mounts Bay Road, near College Creek. The Route 199 booster facility consists of a one-million-gallon ground storage tank, booster pump station, and 15,000-gallon hydropneumatic tank. The booster pump station is equipped with two 40-hp pumps, each rated 600 gpm at 142 feet TDH, and one 100-hp pump rated at 2,000 gpm at 135 Feet TDH. The facility is equipped with a 200 kW standby generator. This facility is primarily used as a peaking facility at this time.

2.3 DEQ Policy

DEQ's groundwater withdrawal permit decisions currently focus on the 80-percent drawdown criterion. As established by 9VAC25-610-110D.3.h:

> *DEQ staff will conduct an evaluation to demonstrate that the proposed withdrawal in combination with all existing lawful withdrawals will not lower water levels, in any confined aquifer that the withdrawal impacts, below a point that represents 80% of the distance between the historical prepumping water levels in the aquifer and the top of the aquifer at the points that are halfway between the proposed withdrawal site and the predicted one foot drawdown contour based on the predicted stabilized effects of the proposed withdrawal. Ground water withdrawal permit applications which do not meet the 80% drawdown criteria will be denied.*

DEQ has also identified other goals/criteria:[2]

- Avoiding saltwater intrusion
- Avoiding land subsidence
- Preventing decline in water levels

To support their decisions, DEQ relies on a groundwater model developed by USGS to simulate withdrawal impacts and water level measurements from monitoring wells.[3] The groundwater model was funded by the Hampton Roads Planning District Commission (HRPDC). As stated in the October 21, 2014 HRPDC Water Resources News, the model indicates that the

> *total amount of withdrawals currently permitted would cause water levels to drop below the management criteria in the regulations. The water level measurements generally show declining water levels for more than a decade. However, several measurements near Franklin show a recent rebound in water levels because the paper mill reduced pumping from 33 to 9 million gallons per day between 2010 and 2012.*[2]

In the previous groundwater model used by DEQ, JCSA's withdrawal did not have a detrimental impact to the aquifer. Withdrawal permits issued since JCSA was first permitted to withdraw may have caused or exasperated the degree in which JCSA withdrawals have caused a violation of the criteria in the updated model.

2.4 Economic Impact of Permitted Groundwater Withdrawal Reduction

Kurt Stephenson of Virginia Tech, in conjunction with Abt Associates Inc., completed a report in August 2014 titled "*An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity*". The report presents the following conclusions:

- A groundwater permit withdrawal reduction would likely increase JCSA's need to purchase water from NNWW and require additional supplies by 2040. The report's delay in the need to acquire additional supplies to 2040 is based on a lower growth predicted by the Weldon Cooper Center and Hampton Roads Planning District Commission for 2040.[4]
- The FFWTF would also be a partially stranded asset. A partially stranded asset is an investment that will not be able to be put to full use. The FFWTF would be a partially stranded asset because JCSA would not be able to use the plant to its full treatment capacity even though they paid for it.

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[2]http://missionh2ovirginia.com/wp-content/uploads/2013/12/Groundwater-Mgmt-Issues-white-paper_2.2014.pdf (Last accessed February 10, 2015)

[3]http://www.hrpdc.org/news/article/october/21/2014/deq-proposes-groundwater-permit-cuts/ (Last accessed February 10, 2015)

[4]Stephenson, Kurt, and Abt Associates Inc. 2014. *An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity*.

- The ability of NNWW to provide additional supply is impacted by their permitted groundwater withdrawal. NNWW has a groundwater withdrawal permit for 7 mgd but average use from 2003 to 2012 was 1.7 mgd. The groundwater is used as a drought emergency supply. NNWW has agreements with JCSA and Williamsburg to provide 4 to 6 mgd. If NNWW's groundwater permit is reduced to 1.7 mgd, they may not have enough water to supply their own customers and maintain these agreements by 2040, assuming demands follow the lower use projections.

Section 3

Water Supply Needs

3.1 Historical Population and Water Demand

JCSA provides water service to approximately 51,700 people. Approximately 98 percent of the customers are served by the Central Water System with the remaining 2 percent served by independent water systems. Table 3-1 provides a summary of the service areas, number of connections, and estimated population. A map indicating the PSA boundary and other service areas is shown on Figure 3-1.

Table 3-1 JCSA Water Service Area Connections (November 2014)

Service Area	Number of Connections	Estimated Population
Central Water System		
• Primary Service Area, Governor's Land, Greensprings West	20,715	50,752
Independent Water Systems		
• Wexford Hills and Riverview Plantation Subdivision	138	341
• Racefield Subdivision	37	91
• Glenwood Acres	34	84
• Kings Village Subdivision	50	124
• Ware Creek Manor Subdivision	65	161
• The Retreat Subdivision	48	119
• Liberty Ridge Subdivision[1]	2	5
• Westport Subdivision[2]		(Under construction)

Notes:

1. Has two connections; operating under DEQ draft permit.
2. Under construction.

This study focuses on the water demands and supply needs of the Central Water System. A summary of the historical groundwater withdrawals and water demands of the Central Water System is presented in Table 3-2. The groundwater withdrawals listed in Table 3-2 reflect the amount of water pumped out of the wells and include the brine concentrate of the treatment process that is discharged into the James River. The finished water demand reflects the amount of water fed into the distribution system.

As shown in Table 3-2, JCSA experienced a slight decline in water use from 2011 through 2013. The decline may be attributed to wetter years, an increase in the number of installations of low-flow fixtures prompted by customer rebates provided by JCSA, and/or economic conditions at the time with watchful eyes on discretionary spending and the construction of privately-owned irrigation wells.

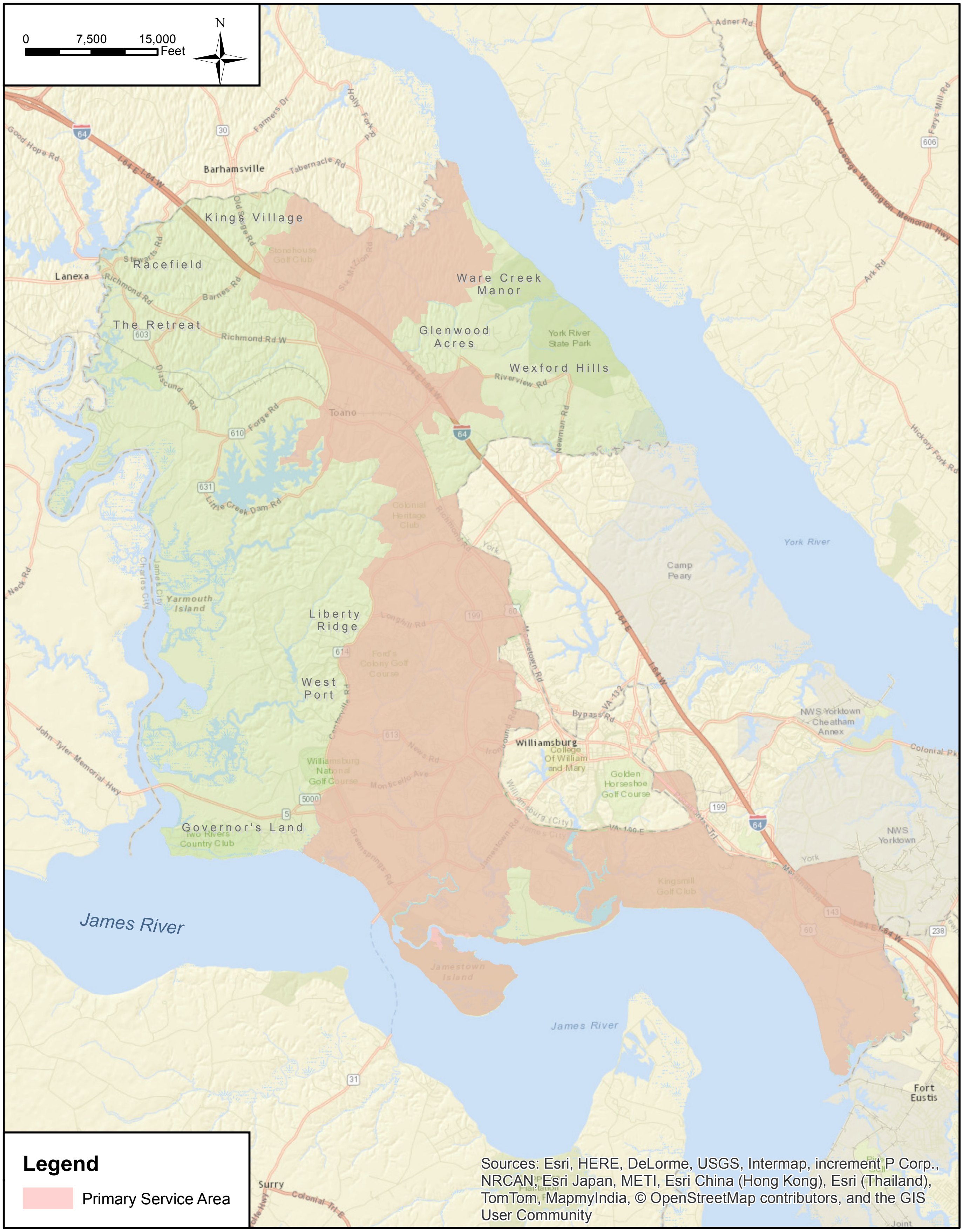

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Figure 3-1
James City County
Primary Service Area

Table 3-2 JCSA Central Water System Historical Groundwater Withdrawal and Water Demands

Year	Number of Connections	Estimated Service Area Population[a]	Average Day Groundwater Withdrawal (mgd)[b]	Peak Month Groundwater Withdrawal (mgd)[b]	Finished Water Average Day Demand (mgd)[c]	Finished Water Peak Month Demand (mgd)[c]
2002[d,g]	14,480	35,476	4.12	6.00	4.12	6.00
2003[d, g]	15,358	37,627	3.85	4.71	3.85	4.71
2004[d, g]	16,249	39,810	4.11	5.34	4.11	5.34
2005[d, e, g]	17,304	42,395	4.85	6.65	4.64	6.20
2006[d, f]	17,718	43,409	5.23	7.33	4.70	6.43
2007	18,193	44,573	5.82	7.30	5.03	6.39
2008	18,553	45,455	5.77	8.02	5.03	7.20
2009	18,829	46,131	5.33	7.29	4.67	6.47
2010	19,172	46,971	5.99	8.29	5.25	7.44
2011	19,544	47,883	5.48	7.11	4.77	6.40
2012	20,294	49,720	5.40	6.83	4.70	6.00
2013	20,325	49,796	5.25	6.51	4.55	5.73
2014	20,732	50,793	5.48	6.90	4.75	6.02

Notes:

a. Number of Connections x 2.45.
b. Water pumped out of the wells.
c. Finished water is water introduced into the distribution system.
d. 2002 through 2006 includes Stonehouse independent water system in the population and demand data.
e. 2005 was the first year of the FFWTF operation.
f. Stonehouse independent water system was combined with the Central Water System in 2006.
g. 2002 through 2005 included connection and demand data for James Terrace which is served by NNWW.

3.2 Population and Water Demand Projections

JCSA indicates that most development will occur in the PSA. The PSA was established by James City County as a growth management tool to encourage higher density development within the PSA to promote efficient use of public facilities and services such as water, sewer, roadways, schools, fire, police stations, and libraries.[1] Development outside the PSA is discouraged. JCSA's water supply plan must ensure that demands of their service area are met and continue to be met in the future.

Available population and water demand projections from the following sources were evaluated to determine JCSA's water supply needs:

- Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.*
- Stephenson, Kurt (Virginia Tech) and Abt Associates Inc. 2014. *An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity* (VT Study).
- JCSA projections based on annual increase in number of connections from Burton & Associates, *James City Service Authority Water & Sewer Rate Study Final Report* completed January 29, 2015.
- Weldon Cooper Center updated population projections released January 27, 2015.

[1] *James City County 2009 Comprehensive Plan*. November 2009. Page 125.

A discussion of the projections provided by these sources follows.

3.2.1 Hampton Roads Regional Water Supply Plan

Water demand projections developed by JCSA for the *Hampton Roads Regional Water Supply Plan* (HRRWSP) are presented in Table 3-3. The projections were estimated assuming a water usage of 106 gallons per capita per day (gpcd) based on JCSA's 2004 to 2008 historical data. The peak water demand was estimated based on a peaking factor of 1.5. JCSA indicated that the projections reflect a pre-2008 booming economy which is not indicative of the current situation.

Table 3-3 Hampton Roads Regional Water Supply Plan JCSA Water Demand Projections

Year	County Population	Estimated Public Water Service Area Population	Percentage of County Population Served	Average Water Demand (mgd)	Peak (Maximum Day) Water Demand (mgd)
2020	80,722	63,370	79%	6.7	10.1
2030	100,757	81,401	81%	8.6	12.9
2040	125,764	103,908	83%	11.0	16.5
2050	156,978	132,000	84%	14.0	21.0

Source: Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Attachment 1, Supply vs Demand 2011Final2_Jul2011.xlsx

3.2.2 VT Study

Kurt Stephenson of Virginia Tech, in conjunction with Abt Associates Inc., evaluated water projections for JCSA in their report titled "*An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity*", completed in August 2014 (VT study). The VT study provided water demand projection scenarios for each decade from 2020 through 2040 based on the following assumptions:

- HRRWSP water demand projections
- HRPDC population estimates and HRRWSP average per capita water usage
- Weldon Cooper Center population estimates and HRRWSP average per capita water usage
- HRPDC population estimates with 14 percent reduction in HRRWSP average per capita usage
- Weldon Cooper Center population estimates with 14 percent reduction in HRRWSP average per capita water usage

A summary of the population estimates is presented in Table 3-4.

Table 3-4 VT Study JCSA Average Water Demand Projections (mgd)

Year	Weldon Cooper Center Population with 2004-2008 Average Per Capita Water Usage	HRPDC Population with 2004-2008 Average Per Capita Water Usage	Weldon Cooper Center Population with 14 Percent Reduction in Average Per Capita Water Usage	HRPDC Population with 14 Percent Reduction in Average Per Capita Water Usage
2020	6.1	5.6	5.2	4.8
2030	7.9	6.5	6.8	5.6
2040	10.2	7.4	8.7	6.3

Source: Stephenson, Kurt, and Abt Associates Inc. 2014. *An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity*. Page 77, Exhibit 4-4.

The VT study indicates that the HRRWSP estimate is the most conservative water demand projection for JCSA. The Weldon Cooper Center population estimates are based on an average annual growth rate of 2.4 percent while the HRPDC population estimates are based on an average annual growth rate of 1.5 percent.[2] JCSA's 2010 average water usage exceeded the 2020 average day demand projection based on the HRPDC and Weldon Cooper Center population estimates with the 14 percent reduction in average per capita water usage, hence the 14 percent reduction appears to be unrealistic.

3.2.3 JCSA Update Based on Annual Increase in Number of Connections

JCSA has updated their water demand projections since the completion of the HRRWSP in 2011. The updated projections are presented in the *James City Service Authority Water & Sewer Rate Study Final Report* completed by Burton and Associates on January 29, 2015. The updated water demand projections were based on a review of the following information:

- Historical data for each customer class from fiscal year (FY) 2009 through FY 2014
- Neighborhood buildout data provided by the James City County Planning Division
- Reasonable growth trends discussed with JCSA staff to determine annual growth based on local environmental and economic conditions

JCSA estimates an increase of 412 connections per year which represents a growth rate slightly less than 2 percent per year.

A summary of the water demand projections is presented in Table 3-5. JCSA's projected finished water average day demands are slightly higher, but follow the same pattern as the VT study projections based on the HRPDC population estimates and HRRWSP per capita usage; the projections are lower than the HRRWSP and VT study projections based on the Weldon Cooper Center population estimates.

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[2] Stephenson, Kurt,and Abt Associates Inc. 2014. An Investigation of the Economic Impacts of Coastal Plain Aquifer Depletion and Actions that may be Needed to Maintain Long-Term Availability and Productivity. Page 32.

Table 3-5 JCSA Water Demand Projections Based on Growth of 412 Connections Per Year

Year	Number of Connections	Estimated Population	Average Day Withdrawal (mgd)	Peak Month Withdrawal (mgd)	Maximum Day Withdrawal (mgd)	Finished Water Average Day Demand (mgd)	Finished Water Maximum Month Demand (mgd)	Finished Water Peak Day Demand (mgd)
2020	23,204	56,850	6.64	8.71	9.96	5.80	7.71	8.70
2022	24,028	58,869	6.88	9.02	10.32	6.01	7.98	9.01
2030	27,324	66,944	7.82	10.26	11.73	6.83	9.08	10.24
2040	31,444	77,038	9.00	11.81	13.50	7.86	10.45	11.79
2050	35,564	87,132	10.18	13.36	15.27	8.89	11.81	13.33

3.2.4 Updated Weldon Cooper Center Population Estimate

The Weldon Cooper Center released updated population estimates for Virginia on January 27, 2015.[3] A summary of the population estimates for James City County is presented in Table 3-6. The July 1, 2014 estimate for James City County was 71,140 in comparison to the April 1, 2010 census estimate of 67,009, reflecting 6.2-percent growth. The updated Weldon Cooper Center population estimates are 7 to 9 percent higher than the 2020 to 2040 population estimates for James City County in the HRRWSP. Hence, water demand projections based on the updated Weldon Cooper Center population estimates would be higher than the projections in the HRRWSP, assuming that the same percentage of the James City County population is included in the water service area.

Table 3-6 Comparison between Weldon Cooper Center Population Estimates for James City County (Released January 27, 2015) and HRRWSP Population Estimates

Year	HRRWSP Population Estimate (July 2011)[a]	Weldon Cooper Center Population Estimate (January 27, 2015)[b]	Percent Difference
2014	---	71,140	---
2020	80,722	86,142	7%
2030	100,757	109,030	8%
2040	125,764	136,736	9%

Notes:

a. Table 3-3
b. http://www.coopercenter.org/demographics/virginia-population-estimates

3.2.5 Demand Summary

Figure 3-2 provides a summary of the available average day demand projections for the JCSA Central Water System. The JCSA projections based on the growth rate of 412 connections per year appear to follow a reasonable growth pattern similar to the VT study demand projection based on the HRPDC population estimate and HRRWSP per capita usage and will be used to determine the minimum water

[3] http://www.coopercenter.org/demographics/virginia-population-estimates (Last accessed February 10, 2015)

supply needs for JCSA. The water demand projections in the HRRWSP were more conservative and will be used to determine the high end of the range of the water supply needs should aggressive growth occur.

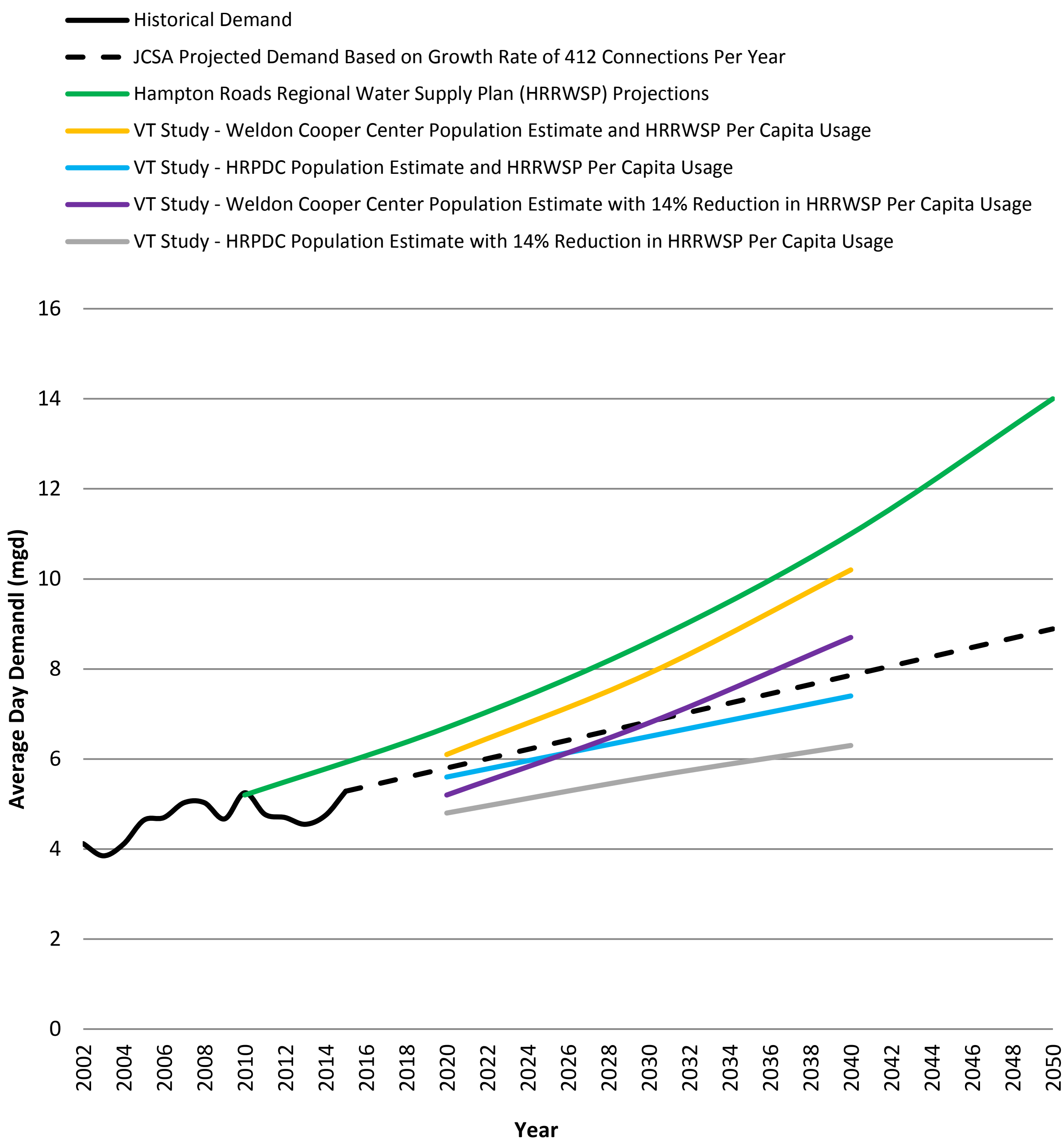

Figure 3-2
JCSA Historical and Projected Average Day Demand

3.3 Water Supply Needs

To meet their water supply needs, the capacity of JCSA's water supply and treatment facilities must satisfy 12VAC5-590-690 which requires the design capacity of the waterworks to exceed the maximum daily water demand of the system, i.e. the peak water demand (finished water peak day demand in Table 3-5). As discussed in Section 2.2, the design capacity of the waterworks is specified in the VDH Waterworks Operation Permit and is based on the limiting water system component, i.e. the lesser of well yield, well pump capacity, booster pump capacity, storage volume, and treatment capacity.

The VDH Waterworks Operation Permit is dependent on the DEQ Groundwater Withdrawal Permit for well yield, but does not correlate one-to-one with the DEQ Groundwater Withdrawal Permit. As discussed in Section 2.2.1, the DEQ Groundwater Withdrawal Permit establishes the limit for the raw water supply and includes the concentrate water in the treatment process while the VDH Waterworks Operation Permit focuses on the limit for the finished water supply, treatment, and distribution system. The current VDH permitted capacity of 9.973 mgd is based on the existing DEQ Groundwater Withdrawal Permit. If DEQ reduces the permitted groundwater withdrawal, VDH will also reduce the permitted capacity in the VDH Waterworks Operation Permit; the permitted groundwater withdrawal will be the limiting factor even if the treatment plant has the design capacity.

The impact of the DEQ permitted groundwater withdrawal on JCSA's water supply needs was evaluated for three scenarios:

- Current DEQ permitted average withdrawal of 8.8 mgd and maximum withdrawal of 11.8 mgd (refer to Section 3.3.1)
- DEQ's proposed reduction in the permitted average withdrawal to 4.0 mgd and estimated maximum withdrawal to 5.4 mgd (refer to Section 3.3.2)
- Revised DEQ permitted average withdrawal of 7.84 mgd to meet the average day demand in the 10-year DEQ permit cycle with an estimated maximum withdrawal of 10.5 mgd (refer to Section 3.3.3)

The ratio of the maximum withdrawal to the average withdrawal in the current DEQ permit was assumed for the reduced and revised DEQ maximum withdrawal permit values. A discussion of the projected water supply deficit for each scenario follows.

3.3.1 Current DEQ Groundwater Withdrawal Permit (Average = 8.8 mgd, Maximum = 11.8 mgd)

Table 3-7 provides a summary of the projected water supply deficit based on the current DEQ Groundwater Withdrawal Permit. As shown in Table 3-7, VDH's maximum day water system capacity of 9.973 mgd is inadequate to meet the projected maximum day demand by 2030 with a projected deficit of 0.3 mgd. The projected deficit was estimated based on the following calculation:

Projected 2030 Peak Day Demand – VDH Permitted Capacity = Finished Water Supply Deficit

10.24 mgd – 9.973 mgd = 0.267 (rounded to 0.3 mgd)

The projected deficit is estimated to increase to 3.4 mgd by 2050.

Table 3-7 Water Supply Deficit with Existing DEQ Permitted Groundwater Withdrawal

A	B	C	D	E	F	G	H	I	J
	DEQ Permitted Groundwater Withdrawal (mgd)		Concentrate Water Withdrawal as Maximum Daily (mgd)	Finished Groundwater Withdrawal as Daily Average (mgd)	Finished Groundwater as Monthly Maximum (mgd)	VDH Permitted Capacity as Maximum Day (mgd)	Average Day Demand (mgd)	Maximum Month Demand (mgd)	Peak Day Demand (mgd)
Year	Avg	Max							
2011	8.8	11.8	0.96	7.84	10.84	9.973	4.77	6.40	7.16
2012	8.8	11.8	0.96	7.84	10.84	9.973	4.70	6.00	7.05
2013	8.8	11.8	0.96	7.84	10.84	9.973	4.55	5.73	6.83
2014	8.8	11.8	0.96	7.84	10.84	9.973	4.75	6.02	7.13
2020	8.8	11.8	0.96	7.84	10.84	9.973	5.80	7.71	8.70
2022	8.8	11.8	0.96	7.84	10.84	9.973	6.01	7.98	9.01
2030	8.8	11.8	0.96	7.84	10.84	9.973	6.83	9.08	10.24
2040	8.8	11.8	0.96	7.84	10.84	9.973	7.86	10.45	11.79
2050	8.8	11.8	0.96	7.84	10.84	9.973	8.89	11.81	13.33

A	K	L	M	N	O	P	Q	R	S
Year	DEQ Deficit for Finished Water (mgd)		DEQ Deficit with Purchase of NNWW 2 mgd Option		DEQ Deficit with Purchase of NNWW 4 mgd Option		VDH Deficit Max (mgd)	VDH Deficit with Purchase of NNWW 2 mgd (2.85 mgd) Option Max (mgd)	VDH Deficit with Purchase of NNWW 4 mgd (5.7 mgd) Option Max (mgd)
	Avg	Max	Avg= 2.0 mgd	Max = 2.85 mgd	Avg = 4.0 mgd	Max = 5.7 mgd			
2011	---	---	---	---	---	---	---	---	---
2012	---	---	---	---	---	---	---	---	---
2013	---	---	---	---	---	---	---	---	---
2014	---	---	---	---	---	---	---	---	---
2020	---	---	---	---	---	---	---	---	---
2022	---	---	---	---	---	---	---	---	---
2030	---	---	---	---	---	---	0.3	---	---
2040	0.0	---	---	---	---	---	1.8	---	---
2050	1.0	0.9	---	---	---	---	3.4	0.5	---

Notes:

A = Proposed Year

B = DEQ permit ending 2012 as annual withdrawal based on an annual daily average of 8.8 mgd.

C = DEQ permit ending 2012 with maximum monthly withdrawal of 11.8 mgd.

D = Concentrate Water Withdrawal as a Max Daily (mgd) = maximum amount of water loss at the FFWTF due to treatment processes.

E = Finished Groundwater Withdrawal as a Daily Average (mgd) = Current DEQ permit for groundwater withdrawal less the concentrate water as an annual daily average = Column B - Column D

F = Finished Groundwater as a Monthly Maximum (mgd) = current DEQ permit for groundwater withdrawal as a monthly maximum = Column C - Column D

G = Current VDH permitted capacity

H = Average Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Average Day Demand by Year

I = Maximum Month (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Maximum Month Demand by Year

J = Peak Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Peak Day Demand by Year

K = DEQ deficit during average day demand by year = Column H - Column E; No Deficit = "---".

L = DEQ deficit during maximum month by year = Column I - Column F; No Deficit = "---".

M DEQ Deficit with Purchase of NNWW 2 mgd Option (2.0 mgd as an Annual Daily Average) = Column K - 2.0: No Deficit = "---".

N = DEQ Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as a Maximum Day) = Column L - 2.85: No Deficit = "---".

O = DEQ Deficit with Purchase of NNWW 4 mgd Option (4.0 mgd as an Annual Daily Average) = Column K - 4.0: No Deficit = "---".

P = DEQ Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as a Maximum Day) = Column L - 5.7: No Deficit = "---".

Q = VDH Deficit = Projected Peak Day less VDH Permitted Capacity = Column J - Column G: No Deficit = "---".

R = VDH Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as Maximum Day) = Column Q - 2.85: No Deficit = "---".

S = VDH Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as Maximum Day) = Column Q - 5.7: No Deficit = "---".

JCSA has also entered into an agreement with Newport News to purchase supplemental water supply. Section 4 provides details of the Newport News Water Purchase Agreement. JCSA has the right to purchase an average of 4 mgd from NNWW during drought conditions and 5 mgd during non-drought conditions with a peak delivery of 5.70 mgd on a monthly average. With a supplemental peak delivery of 5.70 mgd from NNWW, the existing system is adequate to meet the projected maximum day demand through 2050. However, JCSA must make a second payment by 2019 to retain the right to purchase 4 mgd from NNWW. If JCSA does not make the second payment, JCSA's right will be reduced to an average of 2 mgd during drought conditions and 2.5 mgd during non-drought conditions with a peak delivery of 2.85 mgd. With a supplemental peak delivery of 2.85 mgd, JCSA's existing system will be inadequate to meet the projected maximum day demand by 2050 with a projected deficit of 0.5 mgd. Figure 3-3 provides a graphical representation of the impact of the Newport News Water Purchase Agreement on the water supply deficit of JCSA.

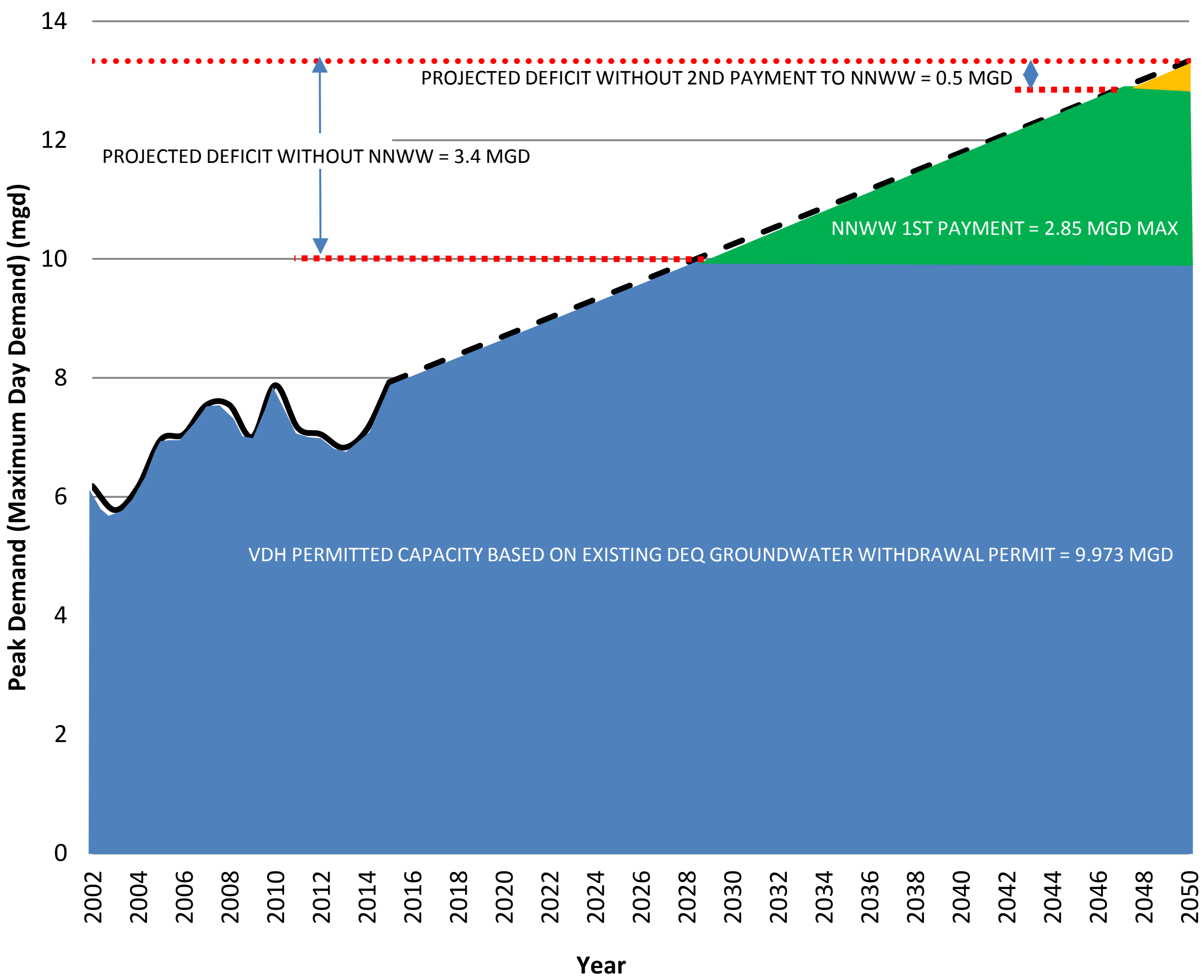

Figure 3-3
Projected Deficit with VDH Permitted Capacity Based on Existing DEQ Groundwater Withdrawal Permit

3.3.2 Reduced DEQ Groundwater Withdrawal Permit (Average = 4.0 mgd, Maximum = 5.4 mgd)

DEQ is proposing to reduce JCSA's permitted average withdrawal to 4.0 mgd. The corresponding maximum withdrawal is estimated to be 5.4 mgd based on the same ratio of the maximum withdrawal to the average withdrawal in the current DEQ Groundwater Withdrawal Permit. With this reduction, it is assumed that the VDH permitted operation capacity will be reduced by the same amount as the groundwater withdrawal reduction. The reduced VDH permitted capacity is estimated to be 5.173 mgd based on the following calculation:

Reduced VDH permitted capacity = Current permitted capacity – DEQ permit reduction
= 9.973 mgd – (8.8 mgd - 4.8 mgd)
= 5.173 mgd

Table 3-8 and Figure 3-4 provide a summary of the projected water supply deficit based on DEQ's proposed reduction. With a reduction in the DEQ permitted average withdrawal to 4.0 mgd and maximum withdrawal to 5.4 mgd, the JCSA water system is inadequate to meet its immediate needs with a deficit of 2.0 mgd, increasing to 8.2 mgd by 2050. With a supplemental peak delivery of 2.85 mgd from NNWW, JCSA's existing system will be inadequate to meet the projected maximum day demand by 2020 with a projected deficit of 0.7 mgd, increasing to 5.3 mgd by 2050. With the peak delivery of 5.70 mgd from NNWW through a second payment, a deficit of 0.9 mgd is projected by 2040, increasing to 2.5 mgd by 2050.

3.3.3 Revised DEQ Groundwater Withdrawal Permit (Average = 7.84 mgd, Maximum = 10.5 mgd)

JCSA's water supply needs were also evaluated with consideration to a revised permit withdrawal that would meet the projected demand for the 10-year duration of the DEQ Groundwater Withdrawal Permit. Since the current permit expired in 2012, it is assumed that the renewed permit will be approved for a 10-year duration and expire in 2022. To meet the projected 2022 peak day demand, a VDH permitted capacity of 9.01 mgd is required. It is assumed that the VDH permitted capacity is reduced from 9.973 to 9.01 mgd due to a reduction in the DEQ groundwater permitted withdrawal from 8.8 to 7.837 mgd (rounded to 7.84 mgd). The corresponding maximum withdrawal is estimated to be 10.5 mgd based on the same ratio of the maximum withdrawal to the average withdrawal in the current DEQ Groundwater Withdrawal Permit.

Table 3-9 and Figure 3-5 provide a summary of the projected water supply deficit based on the revised permitted average withdrawal of 7.84 mgd. With this reduction, the JCSA water system is inadequate to meet their demands prior to 2030 with a projected deficit of 1.2 mgd, increasing to 4.3 mgd by 2050. With a supplemental peak delivery of 2.85 mgd from NNWW, JCSA's existing system will be inadequate to meet the projected maximum day demand by 2050 with a projected deficit of 1.5 mgd; development of an additional water supply source or second payment to Newport News will be required.

Table 3-8 Water Supply Deficit with DEQ Proposed Groundwater Withdrawal Permit Reduction to 4.0 mgd Annual Average

A	B	C	D	E	F	G	H	I	J
	DEQ Permitted Groundwater Withdrawal (mgd)		Concentrate Water Withdrawal as Maximum Daily (mgd)	Finished Groundwater Withdrawal as Daily Average (mgd)	Finished Groundwater as Monthly Maximum (mgd)	VDH Permitted Capacity as Maximum Day (mgd)	Average Day Demand (mgd)	Maximum Month Demand (mgd)	Peak Day Demand (mgd)
Year	Avg	Max							
2011	4.0	5.4	0.5	3.5	4.9	5.173	4.77	6.40	7.16
2012	4.0	5.4	0.5	3.5	4.9	5.173	4.70	6.00	7.05
2013	4.0	5.4	0.5	3.5	4.9	5.173	4.55	5.73	6.83
2014	4.0	5.4	0.5	3.5	4.9	5.173	4.75	6.02	7.13
2020	4.0	5.4	0.5	3.5	4.9	5.173	5.80	7.71	8.70
2022	4.0	5.4	0.5	3.5	4.9	5.173	6.01	7.98	9.01
2030	4.0	5.4	0.5	3.5	4.9	5.173	6.83	9.08	10.24
2040	4.0	5.4	0.5	3.5	4.9	5.173	7.86	10.45	11.79
2050	4.0	5.4	0.5	3.5	4.9	5.173	8.89	11.81	13.33

A	K	L	M	N	O	P	Q	R	S
Year	DEQ Deficit for Finished Water (mgd)		DEQ Deficit with Purchase of NNWW 2 mgd Option		DEQ Deficit with Purchase of NNWW 4 mgd Option		VDH Deficit Max (mgd)	VDH Deficit with Purchase of NNWW 2 mgd (2.85 mgd) Option Max (mgd)	VDH Deficit with Purchase of NNWW 4 mgd (5.7 mgd) Option Max (mgd)
	Avg	Max	Avg= 2.0 mgd	Max = 2.85 mgd	Avg = 4.0 mgd	Max = 5.7 mgd			
2011	1.3	1.5	---	---	---	---	2.0	---	---
2012	1.2	1.1	---	---	---	---	1.9	---	---
2013	1.1	0.8	---	---	---	---	1.7	---	---
2014	1.3	1.1	---	---	---	---	2.0	---	---
2020	2.3	2.8	0.3	---	---	---	3.5	0.7	---
2022	2.5	3.1	0.5	0.2	---	---	3.8	1.0	---
2030	3.3	4.2	1.3	1.3	---	---	5.1	2.2	---
2040	4.4	5.6	2.4	2.7	---	---	6.6	3.8	0.9
2050	5.4	6.9	3.4	4.1	---	1.2	8.2	5.3	2.5

Notes:

A = Proposed Year

B = As proposed by DEQ for 2012 permit renewal, 3.8 mgd to 4.0 mgd for the annual daily average.

C = DEQ proposed 4.0 mgd reduction x 1.34 based on same ratio of max to average in current DEQ Groundwater Withdrawal Permit (11.8/8.8 = 1.34)

D = Concentrate Water Withdrawal as a Max Daily (mgd) = maximum amount of water loss at the FFWTF due to treatment processes.

E = Finished Groundwater Withdrawal as a Daily Average (mgd) = Current DEQ permit for groundwater withdrawal less the concentrate water as an annual daily average = Column B - Column D

F = Finished Groundwater as a Monthly Maximum (mgd) = current DEQ permit for groundwater withdrawal as a monthly maximum = Column C - Column D

G = Current VDH permitted capacity = 9.973 mgd. However, with reductions in DEQ permit the VDH permit will be reduced as well and is estimated as current VDH permit 9.973 mgd less the difference between the current DEQ permit of 8.8 less the value in Column B.

H = Average Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Average Day Demand by Year

I = Maximum Month (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Maximum Month Demand by Year

J = Peak Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Peak Day Demand by Year

K = DEQ deficit during average day demand by year = Column H - Column E; No Deficit = "---".

L = DEQ deficit during maximum month by year = Column I - Column F; No Deficit = "---".

M DEQ Deficit with Purchase of NNWW 2 mgd Option (2.0 mgd as an Annual Daily Average) = Column K - 2.0: No Deficit = "---".

N = DEQ Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as a Maximum Day) = Column L - 2.85: No Deficit = "---".

O = DEQ Deficit with Purchase of NNWW 4 mgd Option (4.0 mgd as an Annual Daily Average) = Column K - 4.0: No Deficit = "---".

P = DEQ Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as a Maximum Day) = Column L - 5.7: No Deficit = "---".

Q = VDH Deficit = Projected Peak Day less VDH Permitted Capacity = Column J - Column G: No Deficit = "---".

R = VDH Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as Maximum Day) = Column Q - 2.85: No Deficit = "---".

S = VDH Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as Maximum Day) = Column Q - 5.7: No Deficit = "---".

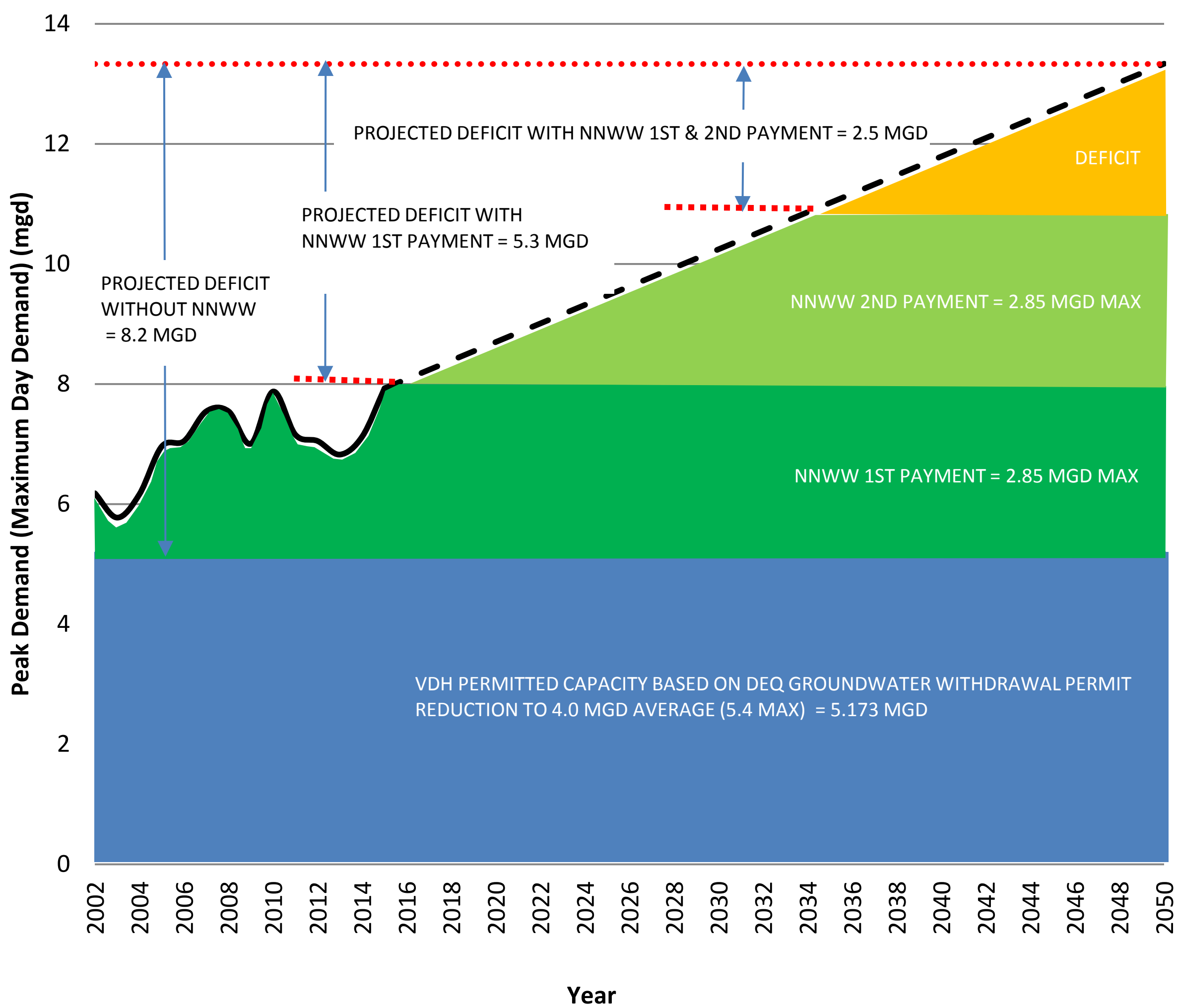

Figure 3-4
Projected Deficit with Revised VDH Permitted Capacity Based on DEQ's Proposed Groundwater Withdrawal Permit Reduction to 4.0 mgd Average (5.4 mgd Maximum)

Table 3-9 Water Supply Deficit with DEQ Revised Groundwater Withdrawal Permit of 7.84 mgd Average

A	B	C	D	E	F	G	H	I	J
	DEQ Permitted Groundwater Withdrawal (mgd)		Concentrate Water Withdrawal as Maximum Daily (mgd)	Finished Groundwater Withdrawal as Daily Average (mgd)	Finished Groundwater as Monthly Maximum (mgd)	VDH Permitted Capacity as Maximum Day (mgd)	Average Day Demand (mgd)	Maximum Month Demand (mgd)	Peak Day Demand (mgd)
Year	Avg	Max							
2011	7.84	10.5	0.96	6.88	9.54	9.01	4.77	6.40	7.16
2012	7.84	10.5	0.96	6.88	9.54	9.01	4.70	6.00	7.05
2013	7.84	10.5	0.96	6.88	9.54	9.01	4.55	5.73	6.83
2014	7.84	10.5	0.96	6.88	9.54	9.01	4.75	6.02	7.13
2020	7.84	10.5	0.96	6.88	9.54	9.01	5.80	7.71	8.70
2022	7.84	10.5	0.96	6.88	9.54	9.01	6.01	7.98	9.01
2030	7.84	10.5	0.96	6.88	9.54	9.01	6.83	9.08	10.24
2040	7.84	10.5	0.96	6.88	9.54	9.01	7.86	10.45	11.79
2050	7.84	10.5	0.96	6.88	9.54	9.01	8.89	11.81	13.33

A	K	L	M	N	O	P	Q	R	S
Year	DEQ Deficit for Finished Water (mgd)		DEQ Deficit with Purchase of NNWW 2 mgd Option		DEQ Deficit with Purchase of NNWW 4 mgd Option		VDH Deficit Max (mgd)	VDH Deficit with Purchase of NNWW 2 mgd (2.85 mgd) Option Max (mgd)	VDH Deficit with Purchase of NNWW 4 mgd (5.7 mgd) Option Max (mgd)
	Avg	Max	Avg = 2.0 mgd	Max = 2.85 mgd	Avg = 4.0 mgd	Max = 5.7 mgd			
2011	---	---	---	---	---	---	---	---	---
2012	---	---	---	---	---	---	---	---	---
2013	---	---	---	---	---	---	---	---	---
2014	---	---	---	---	---	---	---	---	---
2020	---	---	---	---	---	---	---	---	---
2022	---	---	---	---	---	---	---	---	---
2030	---	---	---	---	---	---	1.2	---	---
2040	1.0	0.9	---	---	---	---	2.8	---	---
2050	2.0	2.3	0.0	---	---	---	4.3	1.5	---

Notes:

A = Proposed Year

B = Revised permit withdrawal scenario (minimum needed to meet 2022 demand)

C = Revised permit withdrawal in Column B x 1.34 based on same ratio of max to average in current DEQ Groundwater Withdrawal Permit (11.8/8.8 = 1.34)

D = Concentrate Water Withdrawal as a Max Daily (mgd) = maximum amount of water loss at the FFWTF due to treatment processes.

E = Finished Groundwater Withdrawal as a Daily Average (mgd) = Current DEQ permit for groundwater withdrawal less the concentrate water as an annual daily average = Column B - Column D

F = Finished Groundwater as a Monthly Maximum (mgd) = current DEQ permit for groundwater withdrawal as a monthly maximum = Column C - Column D

G = Current VDH permitted capacity = 9.973 mgd. However, with reductions in DEQ permit the VDH permit will be reduced as well and is estimated as current VDH permit 9.973 mgd less the difference between the current DEQ permit of 8.8 less the value in Column B.

H = Average Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Average Day Demand by Year

I = Maximum Month (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Maximum Month Demand by Year

J = Peak Day Demand (mgd) = Refer to Table 3-2 and Table 3-5, Finished Water Peak Day Demand by Year

K = DEQ deficit during average day demand by year = Column H - Column E; No Deficit = "---".

L = DEQ deficit during maximum month by year = Column I - Column F; No Deficit = "---".

M DEQ Deficit with Purchase of NNWW 2 mgd Option (2.0 mgd as an Annual Daily Average) = Column K - 2.0: No Deficit = "---".

N = DEQ Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as a Maximum Day) = Column L - 2.85: No Deficit = "---".

O = DEQ Deficit with Purchase of NNWW 4 mgd Option (4.0 mgd as an Annual Daily Average) = Column K - 4.0: No Deficit = "---".

P = DEQ Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as a Maximum Day) = Column L - 5.7: No Deficit = "---".

Q = VDH Deficit = Projected Peak Day less VDH Permitted Capacity = Column J - Column G: No Deficit = "---".

R = VDH Deficit with Purchase of NNWW 2 mgd Option (2.85 mgd as Maximum Day) = Column Q - 2.85: No Deficit = "---".

S = VDH Deficit with Purchase of NNWW 4 mgd Option (5.7 mgd as Maximum Day) = Column Q - 5.7: No Deficit = "---".

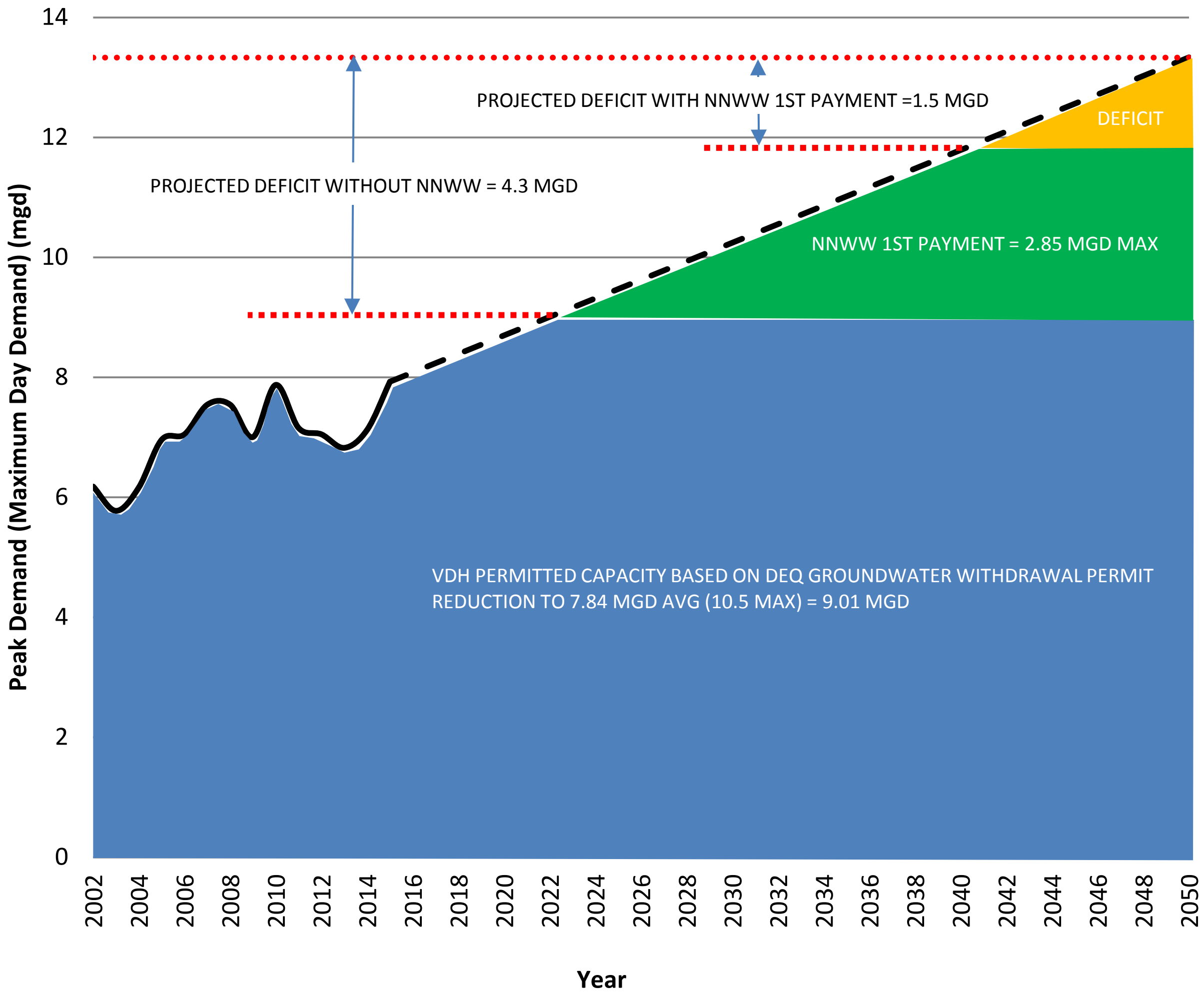

Figure 3-5
Projected Deficit with Revised VDH Permitted Capacity
Based on DEQ's Revised Groundwater Withdrawal Permit of 7.84 mgd Average (10.5 mgd Maximum)

3.3.4 Supply Needs Summary

Table 3-10 provides a summary of JCSA's water supply needs based on the DEQ Groundwater Withdrawal Permit scenarios.

Table 3-10 Water Supply Needs Summary

Description	DEQ Groundwater Withdrawal Permit		NNWW 1^{ST} Payment	NNWW 2nd Payment	Deficit to occur by	Deficit (mgd)	Deficit by 2050
	Average (mgd)	Maximum (mgd)					
Existing DEQ Groundwater Withdrawal Permit[a]	8.8	11.8			2030	0.3	3.4
	8.8	11.8	✓		2050	0.5	0.5
	8.8	11.8	✓	✓	Beyond 2050		
DEQ Proposed Groundwater Withdrawal Permit Reduction[b]	4.0	5.4			2015	2.0	8.2
	4.0	5.4	✓		2020	0.7	5.3
	4.0	5.4	✓	✓	2040	0.9	2.5
Revised DEQ Groundwater Withdrawal Permit[c]	7.84	10.5			2030	1.2	4.3
	7.84	10.5	✓		2050	1.5	1.5
	7.84	10.5	✓	✓	Beyond 2050		

Notes:

a. Table 3-7
b. Table 3-8
c. Table 3-9

With the existing DEQ permitted groundwater withdrawal, JCSA will need additional water supply to meet their projected demands through 2050; the deficit is projected to occur prior to 2030, increasing to 3.4 mgd by 2050. If water is purchased through the first payment to Newport News, the projected deficit is 0.5 mgd by 2050. Water purchased through a second payment to Newport News is projected to meet the water supply needs through 2050.

If the DEQ permitted groundwater annual average withdrawal is reduced from 8.8 mgd to 7.84 mgd average (11.8 mgd to 10.5 mgd maximum), a water supply deficit of 1.2 mgd is projected to occur by 2030, increasing to 4.3 mgd by 2050. With the water purchased through the first payment to Newport News, a deficit of 1.5 mgd is projected by 2050. Water purchased through a second payment to Newport News is projected to meet the water supply needs through 2050.

If DEQ proceeds with their proposed groundwater permitted withdrawal reduction to 4. 0 mgd, a deficit of 2.0 mgd will be immediate, increasing to 8.2 mgd by 2050. With additional water purchased through the first payment to Newport News, a deficit of 0.7 mgd is projected by 2020, increasing to 5.3 mgd by 2050. With water purchased through a second payment to Newport News, a deficit of 0.9 mgd is projected by 2040, increasing to 2.5 mgd by 2050.

The projected deficits presented in Table 3-10 are based on the current anticipated growth trend which assumes an increase of 412 connections per year. Should aggressive growth occur as reflected in the HRRWSP, the projected deficit is estimated to be 0.1 mgd by 2020, increasing to 11 mgd by 2050. With water purchased through the first payment to Newport News, a deficit of 0.1 mgd is projected by 2030, increasing to 8.2 mgd by 2050. With the second payment to Newport News, a deficit of 0.8 mgd is projected by 2040, increasing to 5.3 mgd by 2050. It should be noted that recent population estimates developed by the Weldon Cooper Center reflect a growth rate for James City County that is even higher than the rate assumed in the HRRWSP projections.

Figure 3-6 reflects the range in the projected deficit based on the water demand projection assumptions, DEQ permitted groundwater withdrawal, and NNWW purchase.

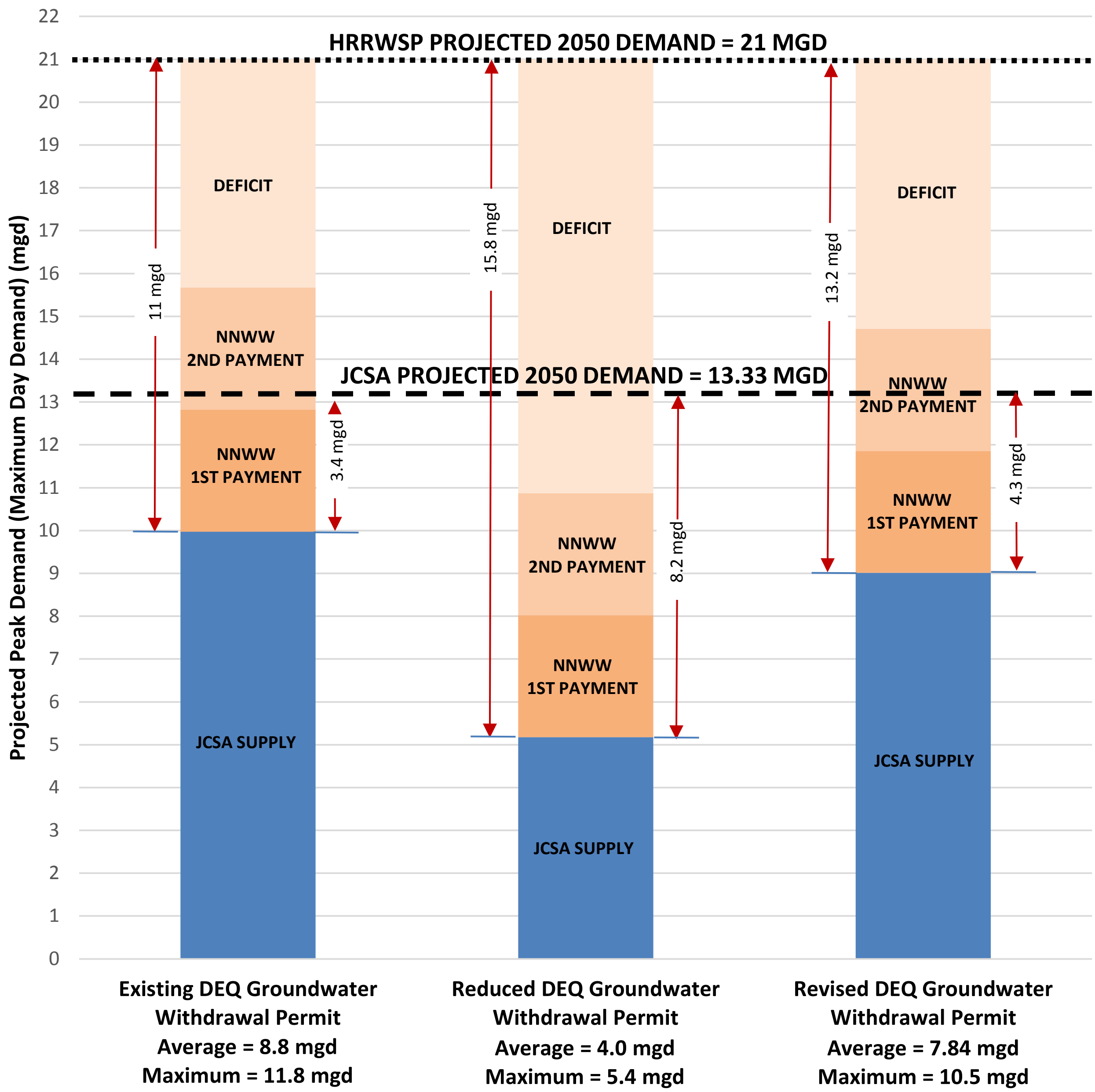

Figure 3-6
Projected 2050 Water Supply Deficit Based on Water Demand Projection, DEQ Groundwater Withdrawal Permit, and NNWW Water Purchase Assumptions

Section 4

Newport News Waterworks Water Purchase Agreement

4.1 Project Development Agreement

As a participant in the Lower Peninsula Regional Raw Water Study Group, JCSA supported Newport News in their plan to build the King William Reservoir (refer to Section 6) with the intent to purchase a 20-percent share of the safe yield, i.e. 4 mgd of the 20 mgd safe yield. JCSA recognized the existing groundwater withdrawal permit would not provide sufficient capacity to meet their water supply needs by the time the King William Reservoir would have been constructed. Newport News indicated a willingness to supplement JCSA's groundwater supply with treated water from the King William Reservoir or from an alternate source if the reservoir was not implemented. **The water from Newport News or alternate source is intended to meet long-term future demands and is not a replacement for existing groundwater withdrawals.**

As a result, on March 25, 2008, JCSA entered into a Project Development Agreement (PDA) with the City of Newport News to purchase supplemental water. The initial term of the PDA continues until January 1, 2050 at which time it will be automatically renewed for 25 years; the terms and conditions of the PDA may be modified by each party at the time of renewal. Notwithstanding the renewal clause, the PDA shall terminate upon the mutual consent of the governing bodies of the parties. A description of the terms and conditions of the PDA follows.

4.1.1 Treated Water Delivery

Under the PDA, Newport News will provide:

- Average delivery of 4 mgd during drought conditions, system failure, or emergency
- Non-drought delivery (if reservoir capacity is at or above typical drawdown cycle on Drought Tracking Chart) of 5 mgd
- Peak delivery of 5.7 mgd on a monthly average calculated on a 30-day rolling average and up to 6.5 mgd daily, provided 4 mgd is not exceeded in a calendar year or 5 mgd under non-drought conditions.

If the federal government, the Commonwealth of Virginia, or Newport News imposes water use restrictions in response to drought or other emergency conditions, JCSA will also be subject to the water use restriction. The amount of treated water provided to JCSA may be reduced in accordance with the targets specified in the *Water Conservation Management Plan, 2006 Update* prepared by NNWW. As specified in the PDA, "The amount of treated water provided to JCSA at the metered system interconnections may be reduced in accordance with Newport News's tiered reduction targets of 5 percent for Tier 2, 10 percent for Tier 3, and 15 percent for Tier 4."

4.1.2 Delivery Locations

The location of the metered interconnections for treated water delivery was to be determined jointly by Newport News and JCSA. Two potential interconnections were established:

- Route 199 at Mounts Bay Road – interconnection has been completed and is estimated to have a maximum capacity of 2.85 mgd
- Lightfoot area near the James City County/York County boundary – interconnection does not exist and potential location has not been identified.

JCSA will have to make significant water distribution piping improvements, add bulk water storage tanks, upgrade or add additional booster pumps, and add potential chemical treatment to distribute water effectively from these locations; the cost of these improvements will be solely JCSA's responsibility.

4.1.3 Payment

4.1.3.1 Safe Yield Share

To receive their safe yield share of the raw water supply, JCSA is required to pay Newport News $50 million in two installments. The first $25 million was paid in 2008 and funded through revenue bonds; the actual cost of the $25 million was $51.5 million including the debt service. The second $25 million (subject to inflation based on the Engineering News Record Building Cost Index) is due June 30, 2019. JCSA estimates the cost of the second payment of $25 million to be approximately $34 million in 2019 dollars with an actual cost of $60 million to finance. JCSA's safe yield share will be limited to 2 mgd on an annual average if the second payment is not made.

4.1.3.2 Water Treatment Costs

In addition to the safe yield share cost, JCSA must also pay a cost for water treatment and delivery to the two system interconnections. The cost of treatment was $0.70 per 1,000 gallons of water in 2008 and has risen to $1.22 per 1,000 gallons of water in 2014. The cost basis is referenced in Section 3.2.2 of the PDA. Newport News determines the treated water cost each year based on the average operating cost for treatment including labor, chemicals, power, and equipment associated with the delivery of raw water to the treatment plant, water treatment, and delivery to the metered connections. JCSA will be billed monthly for the metered consumption.

JCSA will be required to pay a penalty of 1.5 times the consumption rate that Newport News charges its retail commercial customers for treated water if JCSA exceeds the maximum delivery rate of treated water in any calendar year.

4.1.3.3 Water Distribution System Improvement Costs

Costs for NNWW water distribution improvements including water mains, storage tanks, water meters, and pump stations needed to provide treated water to JCSA at the interconnection will be shared between JCSA and Newport News based on the hydraulic capacity required for each party.

4.1.3.4 Capital Cost for Improvements

JCSA is responsible for paying 20 percent of the capital costs for improvement or replacement of water facilities necessary to comply with regulatory requirements or maintain the safe yield share or operability of the water source. Newport News is required to inform JCSA of planned capital projects and associated costs no later than September 1 annually so that JCSA can include the costs in their upcoming budget. If JCSA does not pay the second installment for the safe yield share discussed in Section 4.1.3.1, their responsibility for the capital cost for improvements will be reduced to 10 percent.

4.1.3.5 Variable and Fixed Operation and Maintenance Costs

JCSA is responsible for paying 20 percent of the variable and fixed operation and maintenance (O&M) costs which is based on their 20-percent safe yield share of the King William Reservoir project. Variable O&M costs are annual costs incurred by Newport News for the maintenance and operation of the raw water supply, which varies based on the amount of raw water pumped and includes electricity and pump maintenance. Fixed O&M costs are annual or recurrent costs incurred by Newport News for the operation and maintenance of the water supply, regardless of whether water is delivered. Fixed O&M costs include permitting requirements, reservoir treatment, watershed maintenance and protection, fishery stocking, monitoring, and reporting. Limitations on the variable and fixed O&M costs that JCSA is required to pay with the cancellation of the King William Reservoir project is described in Section 5.1.4 of the PDA.

4.2 System Interconnection Considerations

4.2.1 Disinfection Compatibility

JCSA applies 12.5 percent sodium hypochlorite solution to disinfect groundwater sources directly connected to the distribution system and to finished water from the FFWTF. NNWW uses chloramines to disinfect finished water from their two water treatment facilities. Blending chloraminated finished water from NNWW with JCSA's chlorinated water is not recommended because of the formation of chlorinated byproducts that are ineffective disinfectants unless breakpoint is achieved and additional chlorine is then added. As a result, disinfectants used by JCSA and NNWW must be compatible. JCSA must convert its other facilities to chloramines (Option 1) or the water received from NNWW must be converted/treated to free chlorine (Option 2).

Figure 4-1 illustrates the reactions between ammonia and chlorine. The left (rising) portion of the solid black curve shows what happens when ammonia and chlorine are combined to form monochloramine at a Cl_2/N ratio up to 4.6:1. At a ratio of 4.6:1, all of the added chlorine is monochloramine, there is no free chlorine, and there is potentially some free ammonia. To completely oxidize the ammonia, 7.6 milligrams (mg) Cl_2 for each mg of ammonia (as N) needs to be added. When more than 7.6 parts of chlorine to ammonia (as N) is added, a free chlorine residual becomes measureable which is the objective of what a chorine "burn" achieves. The indication of possibly some nitrogen tri-chloride (NCl_3) in this region of the figure suggests that if pH is not properly controlled, nitrogen tri-chloride, which is an odorant and eye irritant, can form. This should not be a concern in the JCSA system; however, the groundwater should be checked for ammonia (as N) levels. In the region between 5 and 7.6, extra free chlorine leads to a loss in total chlorine residual. It is anticipated that, should JCSA go to breakpoint chlorination, there would be minimal impacts or risk to health as long as free chlorine residual is kept below 3.0 mg/L. Additional analysis is required to assess the feasibility of implementing breakpoint chlorination. It is recommended that water blending analyses be conducted to confirm that negative effects will not occur with breakpoint chlorination. Potential adverse effects include, but are not limited to Total Trihalomethanes (THMs), Haloacetic Acids (HAA5), Lead and Copper Rule, taste, odor, and color.

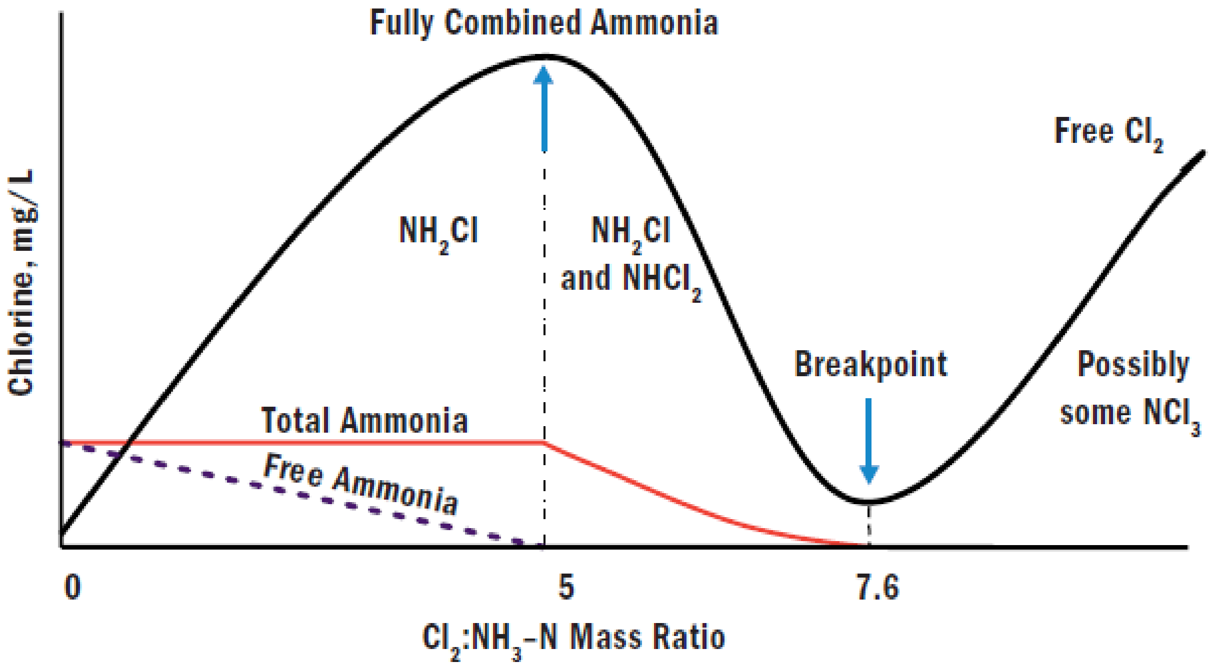

Figure 4-1
Ammonia and Chlorine Reaction
(N. Blute et al, *Opflow*, 2012)

4.2.1.1 Option 1: Converting JCSA to Chloramines

To evaluate the feasibility of converting JCSA's satellite chlorination facilities to chloramination facilities compatible with NNWW finished water, conceptual level cost estimates were developed based on the assumptions below.

Water Supply Locations

JCSA currently monitors free and total chlorine at the following water supply and well (W) locations:

- FFWTF
- Owens- Illinois (W-1)
- The Pottery (W-4)
- Ford's Colony (W-33)
- Stonehouse (W-25)
- Ewell Hall (W-5)
- Canterbury Hills (W-22)
- Kristiansand (W-38)

Ammonia analyzers will be required at these locations.

Distribution Facilities

JCSA also monitors various parameters in the distribution system at the elevated storage tank (ES), booster station (B), pressure reducing valve (PRV) locations, and at well facilities (W). The parameters monitored at each site are listed in Table 4-1.

Table 4-1 Parameters Monitored at Distribution Facilities by SCADA

Site	pH	Conductivity	Temperature	Total Chlorine	Free Chlorine
Stonehouse Commerce Park (ES-01)	✓	✓	✓	✓	✓
Warhill Sports Complex (ES-02)	✓	✓	✓	✓	✓
Ironbound Booster Station (B-27)	✓	✓	✓	✓	✓
Route 199 (B-32)	---	---	---	✓	✓
PRV-1 Below Ground Vault	---	---	✓	---	---
PRV-2 Above Ground in Building	---	---	✓	✓	✓
PRV-3 Above Ground in Building	---	---	✓	✓	✓
Olde Towne Road (W-6)	---	---	✓	✓	✓
Powhatan Secondary (W-12)	---	---	✓	✓	✓
Norge (W-24)	---	---	✓	✓	✓

The total chlorine and pH data will be used to monitor the chloramination effectiveness. Total chlorine concentrations that approach zero indicate the presence of nitrifying bacteria. The pH range impacts the effectiveness of the chlorine and ammonia. Further evaluation using jar tests is required to determine the optimum pH range and ratio of chlorine to ammonia. The addition of pH monitoring equipment at B-32, PRV-2, PRV-3, W-6, W-12, and W-24 is recommended. SCADA control panels are already available at each site for the connection of the pH monitoring equipment.

Temperature is the only parameter monitored at PRV-1; the valve is located in a below-ground vault and does not have room for additional equipment. Additional monitoring equipment is not recommended for this site.

Planning-Level Cost Estimate

The planning-level costs for conversion to chloramination are based on purchasing HACH APA 6000 ammonia and chloramine analyzers at approximately $18,000 each. If desired, the HACH comprehensive warranty can be purchased for $3,500 per analyzer. Features of the warranty include:

- Instrument start-up
- All parts, labor, and travel for on-site repairs
- Four on-site calibrations per year
- Factory recommended maintenance (including required parts)
- Unlimited technical support calls
- Free firmware updates.

The planning-level cost estimates are presented in Table 4-2 and assume the following conditions:

- The satellite facilities currently have the capability to transmit the chloramine reading data to the JCSA Supervisory Control and Data Acquisition (SCADA) system.
- A total of eight ammonia chloramine analyzers will need to be installed.
- Existing chlorine analyzers are currently in operation at each facility.
- Signals from the existing chlorine analyzers are relayed back to SCADA located at the FFWTF and at the Tewning Road Administrative Center.
- The existing chlorine feed pumps are capable of feeding sufficient chlorine to achieve breakpoint chlorination and an additional 3 mg/L for a free chlorine residual that will meet the requirements of the Ground Water Rule (refer to Section 4.2.4.1).
- Sodium hypochlorite and ammonia are a potential hazard if kept in the same place. Space is available in all existing facilities for the installation and operation of aqua ammonia addition feed and storage based on the following assumptions:
  - Walls will need to be installed at the FFWTF and W–25 to separate hypochlorite and aqua ammonia. It is estimated that this will cost approximately $30,000 per facility.
  - W-1, W-4, W-5, W- 33, W-38, and W-22 have separate buildings for sodium hypochlorite. JCSA will have to construct another building on the site for the ammonia. JCSA does not want the sodium hypochlorite and ammonia in the same space. It is estimated that the separate buildings will cost approximately $120,000 per building.
- Installation of the ammonia feed equipment (including analyzers) will be required from a contractor
- Aqua ammonia feed pumps will be required and shall be Prominent pumps or equal. The pumps are approximately $1,800 each plus installation. Two pumps will be required for each facility, one duty and one standby.
- pH monitoring equipment will be installed at B-32, W-6, W-12, W-24, PRV-2, and PRV-3.
- All appurtenances (tubing, flow meters, etc.) will be required. The selected contractor will purchase this equipment from a supplier.
- Aqua ammonia costs are not included in this estimate and will be contracted out.

Table 4-2 Planning-Level Costs for Conversion to Chloramination

Description	Planning-Level Cost Estimate ($)[2]	
Ammonia room at FFWTF and W-25	60,000	
Ammonia building at W-1, W-4, W-5, W-33, W-22, and W-38	720,000	
Ammonia equipment and installation at 8 sites[1,3,4]	310,000	
pH monitoring equipment and installation at 6 sites[5]	8,000	
Miscellaneous piping, valves, and appurtenances	100,000	
Electrical and Instrumentation	120,000	
Subtotal for Prime Contractor		1,320,000
Construction Contingency		330,000
Total Construction Cost in 2015 Dollars		1,650,000
Engineering, Legal, and Financial Fees		250,000
Total Project Cost in 2015 Dollars		1,900,000

Notes:

1. Assumes installation of one HACH APA 6000 chloramine/ammonia analyzer and two aqua ammonia feed pumps (one duty, one standby) at each site.
2. Does not include chemical cost for ammonia
3. Does not include HACH comprehensive warranty which can be purchased at $3,500 per analyzer
4. 8 sites = FFWTF, W-25, W-1, W-4, W-5, W-33, W-22, and W-38
5. 6 sites = B-32, PRV-2, PRV-3, W-6, W-12, W-24

4.2.1.2 Option 2: Converting NNWW to free Chlorine

Breakpoint chlorination to destroy ammonia should also be considered. It is assumed that JCSA would need to feed a chlorine dose of 10 mg/L to achieve a 2.4 mg/L free chlorine residual downstream of the chlorine feedpoint. If the current chemical feed equipment is capable of achieving the 10 mg/L chlorine dose at the facilities, additional chemical costs would be incurred for the additional chlorine dose. Breakpoint chlorination must be achieved prior to distribution to consumers.

JCSA should notify hospitals, dialysis centers, and, pet stores that JCSA is combining source waters that may have potential changes in water quality. It is also essential that pH be maintained at existing levels to not adversely impact other SDWA regulations such as the Lead and Copper Rule or LT2 disinfection byproduct rules. There will be some minor changes to taste and odor. Jar testing is recommended to assess potential water quality changes and disinfectant byproduct formation.

Should JCSA develop a separate surface water treatment facility and close their distribution system off from NNWW supply, then chlorination would be appropriate if the Authority chooses to do so. Otherwise, conversion to chloramination is recommended for disinfection compatibility with the NNWW water supply.

4.2.2 Infrastructure Improvements

In addition to disinfection compatibility improvements, physical infrastructure improvements by JCSA within the existing Central Water System will be required to distribute the flow from either or both of the NNWW interconnections on Route 199 at Mounts Bay Road and in the Lightfoot area near the James City County/York County boundary. It is recommended that JCSA conduct simulations on their hydraulic water model to define specific infrastructure needs. JCSA provided preliminary planning-level costs for infrastructure improvements presented in Table 4-3. Three scenarios were considered:

- Scenario A – 2 mgd from the Mounts Bay Road interconnection
- Scenario B – 2 mgd from the Mounts Bay Road interconnection and 2 mgd from the Lightfoot interconnection
- Scenario C – 4 mgd from the Lightfoot interconnection

Table 4-3 Preliminary Planning-Level Construction Costs for Infrastructure Improvements Necessary for NNWW Interconnections (dollars)

	Scenario A	Scenario B	Scenario C
Mounts Bay Road	**2 mgd**	**2 mgd**	**0**
Lightfoot	**0**	**2 mgd**	**4 mgd**
Upgrade Route 199 Booster Facility (BS-32)	2,200,000	2,200,000	
Build two interconnections similar to Mounts Bay Road interconnection	250,000	250,000	
Elevated storage tank	1,500,000	1,500,000	
One-acre property for distribution storage tank	100,000	100,000	
One-acre land at B-32	100,000	100,000	
Booster facility near Pottery	---	2,500,000	3,000,000
4-5 acres land for booster facility campus	---	1,000,000	1,000,000
JCSA's 20% share of 42,000 feet of NNWW 20 or 24-inch diameter main from Oak Avenue near Penniman Road vicinity up Mooretown Road to hospital ($275/foot)	---	2,310,000	
JCSA's 40% share of 42,000 feet of NNWW 20 or 24-inch diameter main from Oak Avenue near Penniman Road vicinity up Mooretown Road to hospital ($275/foot)	---		4,620,000
JCSA system pipeline upgrades	---	1,000,000	3,500,000
Subtotal for Prime Contractor	4,150,000	10,960,000	12,120,000
Construction Contingency	1,040,000	2,740,000	3,030,000
Total Construction Cost in 2015 Dollars	**5,190,000**	**13,700,000**	**15,150,000**
Engineering, Legal, and Financial Fees	620,000	1,640,000	1,820,000
Total Project Cost	**5,810,000**	**15,340,000**	**16,970,000**

Note: Construction cost of line items provided by JCSA, excluding disinfection compatibility improvements (Refer to Table 4-2)

4.2.3 Financial Impact Summary

A summary of the planning-level cost estimates to implement the NNWW water supply purchase is presented in Table 4-4. It should be noted that the costs presented in Table 4-4 do not include costs for the ammonia. JCSA indicated that for the Scenario A option, the NNWW water supply is intended to serve an area in the vicinity of the Mounts Bay Road interconnection that would be separate from the JCSA water system; hence, disinfection compatibility improvements would not be required for this scenario since the water from the two supplies would not mix.

Table 4-4 Summary of Planning-Level Cost Estimates for NNWW Water Supply Purchase

	Scenario A	Scenario B	Scenario C
Mounts Bay Road	**2 mgd**	**2 mgd**	**0**
Lightfoot	**0**	**2 mgd**	**4 mgd**
2nd Payment[1]	---	$60,000,000	$60,000,000
Infrastructure Improvements[2]	$5,810,000	$15,340,000	$16,970,000
Disinfection Compatibility Improvements[3]	---[4]	$ 1,900,000	$ 1,900,000
Total Project Cost	**$5,810,000**	**$77,240,000**	**$78,870,000**

Note:

1. $25 Million escalated to 2019 dollars (Projected) as $34 million plus cost of debt service.
2. Table 4-3.
3. Table 4-2 for Scenarios B and C.
4. Assumes area served by NNWW is isolated from the JCSA system.

4.2.4 Regulatory Impact

4.2.4.1 Groundwater Regulatory Requirements

Ground Water Rule

EPA published the Ground Water Rule (GWR) in the Federal Register on November 8, 2006. The purpose of the rule is to provide increased protection against microbial pathogens in public water systems that use ground water sources. EPA is particularly concerned about ground water systems that are directly under the influence of surface water and are susceptible to fecal contamination since disease-causing pathogens may be found in fecal contamination. JCSA receives its groundwater from confined aquifers which are not under the influence of surface water. JCSA still falls under the regulatory requirements of the GWR. They are not required to disinfect because of well contamination. JCSA provides the disinfections as a protection for the water in the distribution system.

The GWR applies to public water systems that are served by ground water. The rule also applies to any system that mixes surface and ground water if the ground water is added directly to the distribution system and provided to consumers without treatment.

Final Requirements:

The targeted, risk-based strategy addresses risks through an approach that relies on four major components:

- Periodic sanitary surveys of systems that require the evaluation of eight critical elements of a public water system and the identification of significant deficiencies (e.g., a well located near a leaking septic system)

- Triggered source water monitoring when a system (that does not already treat drinking water to remove 99.99 percent (4-log) of viruses) identifies a positive sample during its Total Coliform Rule monitoring and assessment monitoring (at the option of the state) targeted at high-risk systems
- Corrective action is required for any system with a significant deficiency or source water fecal contamination
- Compliance monitoring to ensure that treatment technology installed to treat drinking water reliably achieves 99.99 percent (4-log) inactivation or removal of viruses

Lead and Copper Rule

Lead and copper enter drinking water primarily through plumbing materials. Exposure to lead and copper may cause health problems ranging from stomach distress to brain damage. On June 7, 1991, EPA published a regulation to control lead and copper in drinking water. This regulation is known as the Lead and Copper Rule (also referred to as the LCR or 1991 Rule).

The treatment technique for the rule requires systems to monitor drinking water at customer taps. If lead concentrations exceed an action level of 15 ppb or copper concentrations exceed an action level of 1.3 parts per million (ppm) in more than 10 percent of customer taps sampled, the system must undertake a number of additional actions to control corrosion. If the action level for lead is exceeded, the system must also inform the public about steps they should take to protect their health and may have to replace lead service lines under their control.

JCSA would be required to return to initial monitoring levels when a new source is added, i.e. NNWW, surface water treatment plant, etc. Current monitoring is conducted every three years at half the number of original sites. Initial monitoring would require all original sites every 6 months for a year then once a year for 3 years; afterwards, monitoring would then be reduced to half the sites every 3 years if the 90th percentile is below the action level. The number of initial sites could also increase from the original number of sites due to the population growth triggers.

Long-Term Revisions to the Lead and Copper Rule

The goal for the LCR Long-Term Revisions is to improve public health protection provided by the LCR by making substantive changes based on topics that were identified in the 2004 National Review, and to streamline the rule requirements. Example categories of potential changes to the rule include:

- Sample site collection criteria and sampling procedures for lead and copper tap monitoring
- Corrosion control treatment and water quality parameter monitoring requirements
- Lead service line replacement requirements
- Schools and day care facilities
- Consecutive system requirements
- Potentially outdated requirements, rule relevancy and simplicity for systems

Stage 2 Disinfectants/Disinfection Byproduct Rule (Stage 2 DBP Rule)

Pathogens, such as *Giardia*, are often found in source water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, and cramps) and other health risks. In many cases, water needs to be disinfected to inactivate (or kill) these microbial pathogens. However, disinfectants like chlorine can react with naturally-occurring materials in the water to form byproducts such as:

- Trihalomethanes (THMs)
- Haloacetic acids (HAAs)
- Chlorite
- Bromate

These byproducts, if consumed in excess of EPA's standard over many years, may lead to increased health risks. EPA has developed the Stage 2 DBP rule to protect public health by limiting exposure to these disinfectant byproducts.

One of the primary changes in the rule is the switch from Running Annual Averaging (RAA) where all samples collected are averaged over a 12-month period to a Location Annual Average (LAA) where individual sites are chosen and averaged over a 12-month period. Also, the compliance LAA levels for Total Trihalomethane (TTHM) and Haloacetic Acids 5 (HAA5) have been lowered.

Total Coliform Rule

There are a variety of bacteria, parasites, and viruses that can potentially cause health problems if humans ingest them in drinking water. Testing water for each of these potential pathogens (disease causing agents) would be difficult and expensive. Instead, water quality and public health workers measure coliform levels. The presence of any coliforms in drinking water suggests that there may be a pathway for pathogens and/or fecal contamination to enter the drinking water distribution system (pipes, storage facilities, etc.).

Total coliforms are a group of closely related bacteria that are (with few exceptions) not harmful to humans. Because total coliforms are common inhabitants of ambient water and may be injured by environmental stresses (e.g., lack of nutrients) and water treatment (e.g., chlorine disinfection) in a manner similar to many pathogens, EPA considers them a useful indicator of these pathogens. Health problems associated with these pathogens include diarrhea, cramps, nausea, and vomiting. Together, these symptoms comprise a general category known as gastroenteritis. Gastroenteritis is not usually serious for a healthy person, but it can lead to more serious problems for people with weakened immune systems, such as the very young, elderly, or immuno-compromised.

For drinking water, total coliforms are used to determine the adequacy of water treatment and the integrity of the distribution system. The absence of total coliforms in the distribution system minimizes the likelihood that fecal pathogens are present. Thus, total coliforms are used to determine the vulnerability of a system to fecal contamination.

To comply with the monthly MCL for total coliforms, JCSA must not find coliforms in more than five percent of the samples they take each month to meet EPA’s standards. If more than five percent of the samples contain coliforms, JCSA operators must report this violation to VDH and the public. If a sample tests positive for total coliforms, JCSA must collect a set of repeat samples located within five or fewer sampling sites adjacent to the location of the routine positive sample within 24 hours. When a routine or repeat sample tests positive for total coliforms, it must also be analyzed for fecal coliforms or E. coli, which are types of coliform bacteria that are directly associated with fresh feces. A positive result for fecal coliforms or E. coli can signify an acute MCL violation, which necessitates rapid VDH and public notification because it represents a direct health risk. Often, an acute violation due to the presence of fecal coliform or E. coli will result in a "boil water" notice.

4.2.4.2 Surface Water Regulatory Requirements

The LCR, TCR, and the Stage 2 DBP Rule requirements for treated surface water are the same as those presented in the Groundwater Regulatory Requirements section. Should JCSA wish to evaluate treating surface water in the future, the following rules will apply:

Filter Backwash Recycling Rule

In May 2001, EPA released a rule governing the process of recycling waste water generated by the backwashing of drinking water filters. The Filter Backwash Recycling Rule (FBRR) is required by the Safe Drinking Water Act as one method of reducing the risks posed to consumers by microbial contaminants that may be present in public drinking water supplies.

Long Term 2 Enhanced Surface Water Treatment Rule (LT2)

Pathogens, such as *Giardia* and *Cryptosporidium*, are often found in water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, and cramps) and other health risks. In many cases, this water needs to be disinfected through the use of additives such as chlorine to inactivate (or kill) microbial pathogens.

Cryptosporidium is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks. Consuming water with *Cryptosporidium* can cause gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).

The purpose of the LT2 rule is to reduce disease incidence associated with *Cryptosporidium* and other pathogenic microorganisms in drinking water. The rule applies to all public water systems that use surface water or ground water that are under the direct influence of surface water. The rule will bolster existing regulations and provide a higher level of protection of the drinking water supply by:

- Targeting additional *Cryptosporidium* treatment requirements to higher risk systems
- Requiring provisions to reduce risks from uncovered finished water storage facilities
- Providing provisions to ensure that systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts

Should JCSA purchase untreated water from NNWW or develop its own surface water source, these regulations will all need to be considered in the design phase of the surface water treatment facility and will impact the selection of the proper equipment. Additional water quality monitoring will be required based on the surface water regulatory requirements and should be added to JCSA's budget for a new surface water supply source.

Section 5

Ware Creek Reservoir

JCSA identified the Ware Creek Reservoir as a water supply option in the 1980s. A description of the Ware Creek Reservoir project and the reasons why it was not considered a viable option is provided in this section. The information is based on a review of the following sources:

- Final Determination of the U.S. Environmental Protection Agency's Assistant Administrator for Water Pursuant to Section 404(c) of the Clean Water Act Concerning the Proposed Ware Creek Water Supply Impoundment, James City County, Virginia. (http://water.epa.gov/lawsregs/guidance/wetlands/upload/WareCreekFD.pdf (Last accessed February 10, 2015)

- http://www.epa.gov/owow/wetlands/pdf/Ware_Creek_Summary.pdf (Last accessed February 10, 2015)

5.1 Description

The Ware Creek Reservoir project was a proposed impoundment along the James City County/New Kent County border. The Ware Creek Reservoir project involved the construction of an earthen dam on a northwest-southeast axis across Ware Creek, approximately 1,000 feet downstream from its confluence with France Swamp and 4.72 miles upstream of the Ware Creek confluence with York River. The dam would have been 1,450 feet long with a crest width of 40 feet, base width of 300 feet, and crest elevation +48 feet mean sea level. The reservoir would have had a surface area of 1,217 acres, an average water depth of 16 feet, and a volume of 6,355 million gallons at a normal pool elevation of +35 feet mean sea level. The Ware Creek Reservoir's safe yield was estimated to be 9.4 mgd. The average stream flow at the dam was estimated to be 12.3 mgd (19.2 cubic feet per second(cfs)) with a maximum flow of 12,485 cfs.

The majority of the Ware Creek drainage basin would have been located upstream of the proposed dam location, and at inception was undeveloped, and characterized by upland areas with hardwood and mixed pine-hardwood trees. Since the 1980s, the area has seen an increase in development within the proposed watershed. The wetland environment would have been relatively undisturbed, supporting a diverse wildlife population. There were sightings of three significant bird species in the vicinity of the Ware Creek wetland area: Southern Bald Eagles, Great Blue Herons, and Black Duck. The Southern Bald Eagle was not known to nest in the area; however, there were anecdotal references to its sighting. The species prefers open water environment and is likely to limit its activities to portions of the watershed that provide suitable habitat. The Great Blue Heron has a rookery in France Swamp and has low tolerance for human disturbance. The Black Duck has experienced decline in population due to habitat loss.

Construction of the Ware Creek Reservoir would have inundated 425 acres of waters of the United States (381 acres vegetated with scrub-shrub, herbaceous or forested wetland and 44 acres of open water less than two meters deep) and 792 acres of primarily forested upland. The project would have eliminated over 38 percent of the vegetated wetland communities in the Ware Creek watershed. The destruction of the wetlands could have had an adverse impact on the wildlife.

Ware Creek discharges into a tidal brackish section of the York River and experiences fluctuations in salinity. The National Marine Fisheries Service indicated that Ware Creek is suitable for spawning of anadromous fish species. The water supply withdrawal would have reduced the stream flow downstream of the dam from 12.4 to 3.3 mgd. The reduction would have affected the downstream wetland communities and nutrient transport capabilities of the ecology.

James City County developed a mitigation plan to offset the adverse impacts of the project. The proposed mitigation plan included:

- Wetland creation and wetland and upland preservation in the Ware Creek/York River watershed
- Creation of nesting habitat as mitigation for an existing Great Blue Heron rookery in the Ware Creek watershed
- Wetland creation and breaching on an existing dam in Yarmouth Creek to reconnect wetlands and reestablish anadromous fish access in the James River watershed
- Extensive preservation of wetlands and uplands in Yarmouth and Powhatan Creeks in the James River watershed.

The Recommended Determination indicated that "in all probability, James City County's is the most comprehensive mitigation plan put forth to date in this region."[1] Although EPA commended James City County for their effort, EPA concluded in the Final Determination issued on July 10, 1989 that "the proposed mitigation plan would not adequately offset the anticipated adverse impacts to wildlife" and that "there are practicable, less environmentally damaging alternatives to satisfy James City County's projected water supply needs." The use of groundwater from the lower aquifer was identified as a viable source which resulted in the construction of the FFWTF.

5.2 Reasons for Abandonment

5.2.1 Local Water Supply Source

In September 1989, James City County filed a complaint in U.S. District Court to vacate EPA's Final Determination issued on July 10, 1989. The District Court granted the relief to James City County based on the finding that the County had no practicable water supply alternative available. On March 1, 1991, the U. S. Army Corps of Engineers issued a Section 404 permit to James City County for the Ware Creek Reservoir construction.

EPA appealed the Corps of Engineers' permit approval. On January 29, 1992, the Court of Appeals reversed the District Court's decision and remanded the case to EPA. The Court requested EPA to determine if the adverse environmental impacts justify the restriction for site development even if there were no other practicable water supply alternatives for the County. On March 27, 1992, the Court reaffirmed EPA's 1989 determination and withdrew the Section 404 permit.

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[1] Final Determination of the U.S. Environmental Protection Agency's Assistant Administrator for Water Pursuant to Section 404(c) of the Clean Water Act Concerning the Proposed Ware Creek Water Supply Impoundment, James City County, Virginia. Page 44.

James City County filed suit for review of the Remand Determination and the District Court supported the County. EPA appealed the decision and filed with the Fourth Circuit to reverse the District Court's decision. On December 23, 1993, the Fourth Circuit upheld the 1989 Final Determination.

James City County filed for a rehearing in banc of the case and was denied on March 25, 1994. On June 22, 1994, the County filed a Writ of Certiorari for the U.S. Supreme Court to hear the case, but was denied certiorari on October 3, 1994. As a result, the County abandoned their consideration of the Ware Creek Reservoir as a local water supply source.

5.2.2 Regional Water Supply Source

Ware Creek Reservoir was reconsidered as a potential water supply for the Regional Raw Water Study Group (RRWSG). The RRWSG formed in 1987 to evaluate water supply needs of the Lower Peninsula area of southeast Virginia and to develop a plan for a regional water supply. James City County is part of the RRWSG and would receive water from the Ware Creek Reservoir. The Ware Creek Reservoir was evaluated in conjunction with the King William Reservoir project which is discussed in Section 6.

Ware Creek Reservoir was considered with pumpovers from the Pamunkey, Mattaponi, Chickahominy, and/or James rivers. The RRWSG considered Ware Creek Reservoir as the least favorable of the reservoir alternatives (including King William and Black Creek) for similar reasons identified in the local supply final determination, as well as the following:

- Largest reduction in streamflow levels below a proposed dam site
- Large impact on hydrologic and salinity regimes of wetlands below a proposed dam site
- Questionable long-term water quality due to intense development in the Stonehouse community
- Negative impact on the largest and most diverse area of wetlands and largest population of Great Blue Heron
- Ten percent reduction in treated water safe yield benefit compared to King William Reservoir
- Largest impact on number of existing roadways

The Ware Creek Reservoir was eliminated from further evaluation as a regional water supply source for James City County and other members of the RRWSG.

Section 6
King William Reservoir

The King William Reservoir was identified as a potential regional water supply source for the RRWSG in the 1980s. JCSA had planned on purchasing 4 mgd of the King William Reservoir's safe yield to meet their future water supply needs. A description of the King William Reservoir project and why it was abandoned is provided in this section. The information is based on a review of the following sources:

- Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*.
- http://www.virginiaplaces.org/watersheds/kwreservoir.html (Last accessed February 10, 2015)

6.1 Description

The King William Reservoir would have involved the construction of a 78-foot high, 1,700-foot long dam across Cohoke Creek, approximately 3.5 miles upstream of the Cohoke Millpond dam and 0.2 miles downstream of the Route 626 crossing in King William County. The reservoir would have encompassed a 1,526-acre surface area with a volume of 12.2 billion gallons at a normal pool elevation of +96 feet mean sea level.

The King William Reservoir project also involved a pumpover from Mattaponi River since Cohoke Creek did not have sufficient flow for the reservoir. The raw water intake structure and pump station would be located on the Mattaponi River at Scotland Landing, upstream of the fresh/brackish water boundary. Water would have be pumped to the King William Reservoir through 1.5 miles of 54-inch diameter pipe.

Construction of the King William Reservoir would have inundated 403 acres of waters of the United States and potentially affected two threatened plant species, the sensitive joint-vetch and the small whorled pogonia, which may be present. The Mattaponi tribe indicated that a secret sacred site would be destroyed by the reservoir. Fisheries on the Mattaponi River may also be threatened.

A $31 million wetland mitigation plan was prepared to offset the adverse impacts of the project. The Virginia Marine Resources Commission permit allowing the intake to be constructed was approved in 2004. The U.S. Army Corps of Engineers (USACE) approved the permit to construct the reservoir in 2005.

6.2 Reasons for Abandonment

Since its inception, the King William Reservoir project had undergone controversial, regulatory approvals. The USACE's approval of the Section 404 permit in 2005 was challenged by The Alliance to Save the Mattaponi River, the Chesapeake Bay Foundation, the Sierra Club, and the Southern Environmental Law Center. On March 31, 2009, the Federal District Court rejected the USACE's 2005 approval of the Section 404 permit. On April 30, 2009, the USACE directed Newport News to stop work on the project. The project managers indicated that there was a risk that the DEQ and Virginia

Marine Resources Commission permits would expire and that the USACE would not issue a new Section 404 permit. Newport News abandoned the King William Reservoir project on September 22, 2009.

Section 7
York River

The York River flows along the northeast boundary of James City County. The York River has a drainage basin that encompasses 2,626 square miles; the headwaters begin in Orange County and flows southeasterly into Chesapeake Bay.[1]

An investigation of the York River as a potential water supply source for JCSA was conducted based on information from the following sources:

- Buchart Horn, Inc. and Watek Engineering. 2005. *A Brief Feasibility Study, Use of the York or James River for Future Water Supply*.
- Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.*
- Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*.
- Rice, Karen C., Mark R. Bennett, and Jian Shen. USGS Open File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.*
- U.S. Environmental Protection Agency. 2014. STORET.
- Virginia Department of Environmental Quality. 2013. *Status of Virginia's Water Resources, A Report on Virginia's Water Resources Management Activities.*
- Virginia Institute of Marine Sciences, Virginia Estuarine and Coastal Observing System (VECOS) (http://web2.vims.edu/vecos/StationDetail.aspx?param=YRK006.77&program=CMON)

7.1 Existing Withdrawals

The Yorktown Fossil Power Plant, which is located in York County, uses water from the York River for cooling water.[2] The Virginia Water Protection Permit established a 2007 use estimate of 817 mgd. DEQ reported an average withdrawal of 691 mgd with a 2012 withdrawal of 531 mgd.[3] Most of the water is returned to the York River.

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[1] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 3-5.

[2] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 1-9.

[3] Virginia Department of Environmental Quality. 2013. *Status of Virginia's Water Resources, A Report on Virginia's Water Resources Management Activities.*

7.2 Existing VPDES Discharges

There were no VPDES permitted facilities identified in the section of the York River that flows along the James City County boundary.[4] Approximately 10 miles upstream from York River State Park, there are two VPDES discharges into the Pamunkey River that feed into the York River at West Point: a pulp mill owned by Rocktenn CP LLC - West Point (VPDES Permit No. VA0003115) and the Hampton Roads Sanitary District (HRSD) West Point sewage treatment plant (VPDES Permit No. VA0075434).[5] The VPDES discharge locations are shown on Figure 7-1.

7.3 Previous Studies

7.3.1 Lower Virginia Peninsula Regional Raw Water Supply Plan EIS

The York River was evaluated as a potential water supply source in the Lower Virginia Peninsula Regional Water Supply Plan EIS. The raw water intake structure and pump station were proposed to be located in James City County, midway between Sycamore Landing and York River State Park, approximately 23 miles upstream from the mouth of the York River. The conceptualized facility included an 85-mgd raw water intake and a 44-mgd RO plant located near Williamsburg's Waller Mill water treatment plant in York County. A 41-mgd capacity concentrate disposal pipeline from the RO plant to the York River with an outfall located near HRSD's York River sewage treatment plant were also proposed.

The proposed pretreatment process included screening, conventional sedimentation and filtration, and chemical addition for scale control and pH adjustment. The pretreated water would flow into an RO unit. Chlorine for disinfection, chemical conditioning for corrosion control, and degassing would be applied to the permeate. The feed water was assumed to have a maximum total dissolved solids (TDS) content of 23,500 mg/L. With a water recovery rate of 52 percent and a TDS rejection rate of 99 percent, a maximum TDS level of 46,500 mg/L was estimated for the concentrate stream.

As stated in the EIS, the York River was considered technologically and economically infeasible at the time as a regional water supply source due to raw water quality variability, particularly fluctuating salinity levels, and treatment control concerns. However, since the time that the EIS was completed in 1997, technological advancements have occurred that allow RO systems to cope better with fluctuations in salinity levels and makes RO technology a more viable option for treating the York River today. These technological advancements include improvements in RO membrane performance including dramatic improvements in RO membrane rejection and the rated permeate production per RO element. In addition, new low energy and ultra-low energy membranes have been developed which help bridge the performance gap between brackish water and seawater RO membranes. These membranes are suited better for treating tidally influenced water sources such as the York, James, and Chickahominy rivers. Variable frequency drives are more reliable and are used more extensively today than at the time the EIS was published. Variable frequency drives provide much greater flexibility in adjusting the flow rate and operating pressure of the high pressure RO pumps in order to reliably maintain the design capacity and required product quality under fluctuating conditions of feed water TDS and temperature. More efficient energy recovery devices have also been developed which help to significantly reduce the cost of RO treatment.

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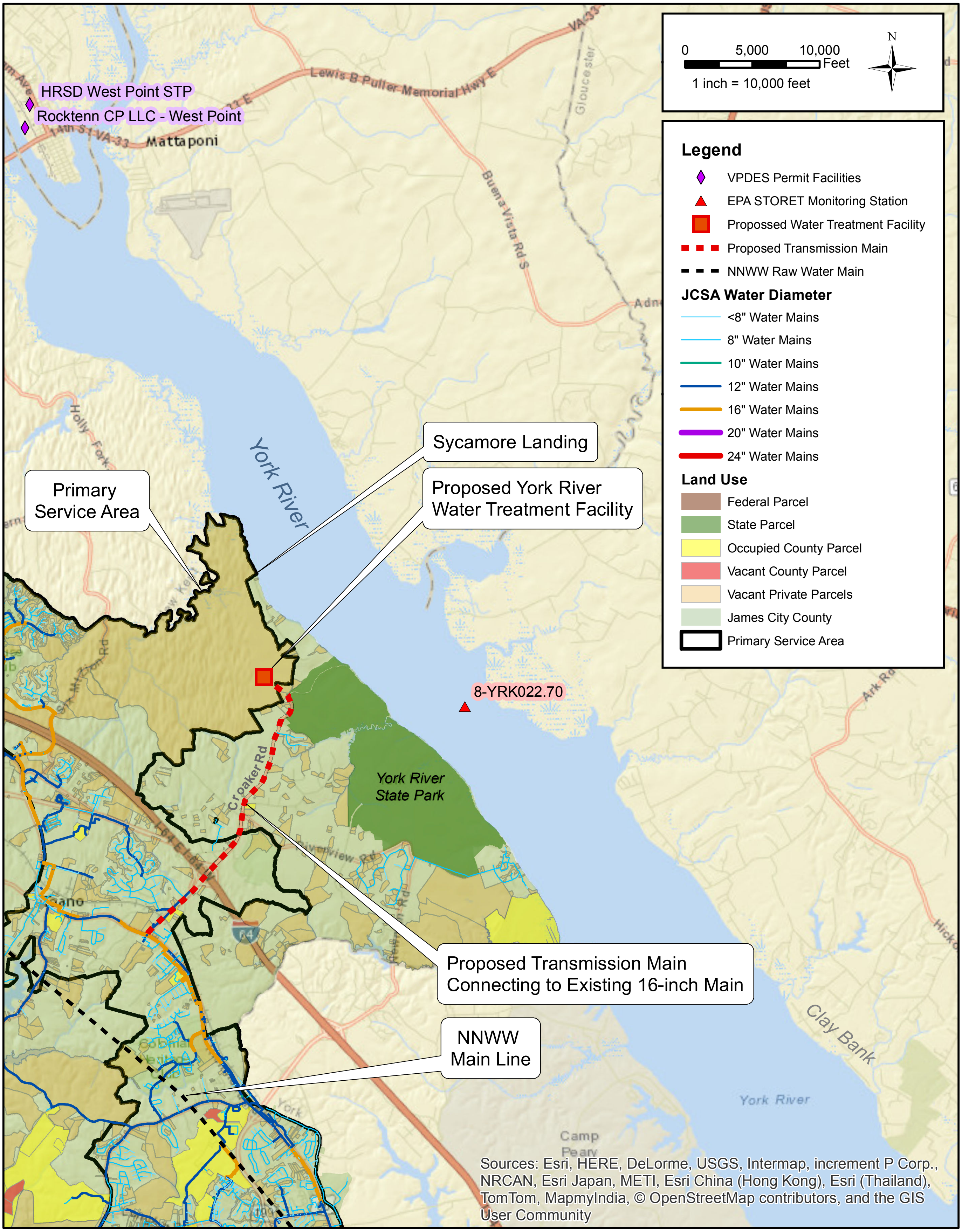
[4] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Map 3-15.

[5] http://watersgeo.epa.gov/mwm/(Last accessed November 13, 2014)



CDM Smith

Figure 7-1
York River
Potential Water Supply Source

7.3.2 Brief Feasibility Study for JCSA Future Water Supply (2005)

A brief feasibility study of the York River as a future water supply for JCSA was completed in November 2005 by Buchart Horn, Inc. and Watek Engineering Corporation. The study considered the use of the York River as a water source for the northern portion of the County with an 8-mgd water treatment facility constructed in the Croaker Road area. Raw water quality was based on data collected from DEQ Water Quality Monitoring Station 8-YRK022.70.

York River was characterized as essentially fresh water with salinity increasing with depth. Salinity ranged from 4.7 to 16.6 g/L (4.7 to 16.6 parts per thousand (ppt)) with an average of 12.3 g/L (12.3 ppt). A maximum salinity of 16.6 ppt correlates to a TDS of approximately 16,600 mg/L which is considerably lower than the TDS of 23,500 mg/L reported in the EIS; the discrepancy between the TDS and salinity in the Buchart Horn Watek Engineering Corporation study appears questionable.

A multi-port intake was suggested to provide flexibility. Riverbank filtration was also proposed as an option to improve raw water quality, reduce pretreatment costs, and potentially simplify the permitting process by not directly impacting the waterway. Reverse osmosis was recommended for desalination. A recovery of 55 percent was assumed.

The study recommended a pretreatment process consisting of coagulation/flocculation, sedimentation followed by microfiltration, and reverse osmosis. The conceptual-level construction cost estimate for the treatment facility was $59 million and included 8 million gallons of distribution storage. The conceptual-level operating cost estimate was $3.20 per 1,000 gallons of water produced.

7.4 Evaluation of Treatment Options

7.4.1 Water Quality Evaluation

For the purpose of this study, the location of a raw water intake in the York River close to Croaker Road was assumed. Water quality data from the following sources were reviewed to determine treatment requirements:

- U.S. Environmental Protection Agency. 2014. STORET.
- Rice, Karen C., Mark R. Bennett, and Jian Shen. USGS Open File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.*
- Virginia Institute of Marine Sciences, Virginia Estuarine and Coastal Observing System (VECOS) website

Table 7-1 presents a summary of the water quality data from DEQ Water Quality Monitoring Station 8-YRK022.70. Intermittent sampling was conducted at this station from March 15, 2005 to December 5, 2013.

Table 7-1 DEQ Water Monitoring Station 8-YRK022.70 Available Data (2005-2013)

Parameter	Units	Minimum	Maximum	Average	Number of Samples
Ammonia as N	mg/L	0.024	0.163	0.076	8
Carbon	mg/L	0.997	4.55	2.439	8
Dissolved oxygen (DO)	mg/L	9.26	9.76	9.46	6
Enterococcus	cfu/100ml	25	25	25	4
Fecal Coliform	cfu/100ml	25	25	25	4
Fixed suspended solids	mg/L	14	143	58	8
Inorganic nitrogen (nitrate and nitrite) as N	mg/L	0.077	0.245	0.127	8
Nitrate as N	mg/L	0.042	0.245	0.116	8
Nitrite as N	mg/L	0.002	0.038	0.011	8
Nitrogen as N	mg/L	0.081	0.556	0.378	16
pH		7.48	7.82	7.70	16
Phosphorus as P	mg/L	0.002	0.053	0.022	16
Phosphorus, Particulate Organic as P	mg/L	0.0189	0.1508	0.0771	8
Salinity	Ppt	7.21	16.8	14.6	16
Silica	mg/L	2.8	5.4	4.4	4
Specific conductance	uS/cm	12570	27488	24089	16
Temperature, water	deg C	8.29	11.77	9.37	16
Total suspended solids (TSS)	mg/L	19	163	69	8
Total volatile solids	mg/L	4	20	11	8
Turbidity	NTU	8.9	85	37	8

Source: U.S. Environmental Protection Agency. 2014. STORET database.
Units: mg/L = milligrams per liter
cfu = colony-forming unit
deg C = degree Celsius
ppt = parts per thousand
uS/cm = Microsiemens Per Centimeter
NTU = nephelometric turbidity unit

The USGS Open-File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay,* provides salinity data at the head of the York estuary from 1998 to 2008. A summary of the salinity data from the USGS report is presented in Table 7-2. The highest salinity observed during this period was 14.5 ppt in January 2002. The report also provides information on the 31-day mean salinity along the York River for October 2002 (a dry-year scenario) based on the distance upstream of the river mouth. The 31-day mean salinity was estimated to be 13.1 ppt at the head of the river and 14.5 ppt at the proposed intake location. The maximum salinity of 14.5 ppt at the head of the river is approximately 10 percent higher than the 31-day mean salinity of 13.1 ppt. Hence, for the purposes of this study, the maximum salinity at the York River intake was estimated to be 16 ppt, i.e. 10 percent higher than the 31-day mean salinity of 14.5 ppt. The estimated maximum salinity of 16 ppt compares well with the maximum salinity of 16.8 ppt reported in Table 7-1 for DEQ Water Quality Monitoring Station 8-YRK022.70.

Table 7-2 USGS York River Salinity Data

Parameter	Head of the York River	Proposed WTF Site
Maximum Salinity – January 2002 based on 1998 to 2008 data	14.5 ppt[a]	16.0 ppt[d]
31-Day Mean Salinity – October 2002	13.1 ppt[b]	14.5 ppt[c]

Source: Rice, Karen C., Mark R. Bennett, and Jian Shen. USGS Open File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.* Parameters estimate basis with reference to figures in the USGS report:

a. Figure 10
b. Figure 14
c. Figure 14 with WTF intake estimated to be 43 km (27 mi) from mouth of the river
d. Estimated assuming same percent relationship of maximum to 31-day mean salinity as head of the York River.

The Virginia Institute of Marine Sciences, VECOS database provides the following average values for 2005 for monitoring station TSK:

- Salinity = 10 ppt
- Temperature = 16.7 degrees Celsius (62 degrees Fahrenheit)
- Turbidity = 58 NTU

The VECOS salinity of 10 ppt is lower than the average salinity of 14.6 ppt for DEQ Water Quality Monitoring Station 8-YRK022.70. The VECOS temperature of 16.7 degrees Celsius is higher than the DEQ average of 9.37 degrees Celsius. Likewise, the turbidity of 58 NTU is higher than the DEQ average of 11 NTU. It should be noted, however, that the DEQ average is based on a limited number of samples (8 to 16 samples), while the VECOS TSK station has been continuously collecting data at 15 minute intervals since 1995. For this reason, the VECOS data has been used to establish the design criteria for the York River site.

Please note that while salinity values are typically reported in ppt, TDS and ionic concentrations are usually reported in mg/L or ppm (parts per million). For clean water that does not have high concentrations of dissolved organics, TDS values in mg/L or ppm should be approximately equal to salinity values in ppt times one thousand.

7.4.2 Recommended Treatment

Based on the water quality evaluation, RO treatment is recommended for the York River to reduce the level of TDS from values ranging up to 16,800 mg/L to drinking water quality levels with TDS of less than 350 mg/L as JCSA's established water quality goal.[6] While others have evaluated RO treatment for the York and James rivers and concluded that this technology would not be cost effective, RO membrane technology has improved significantly over the past 10 to 20 years. Salt passage through seawater RO membranes has decreased by over 50 percent in the past 10 years. In addition, new low energy and ultra-low energy membranes have been developed in the last 10 years that can reduce power consumption by 17.5 percent and 29 percent, respectively, versus conventional seawater RO

[6] American Membrane Technology Association. 2006. *New Facilities Solutions.* "Five Forks RO plant in Virginia after 1 year of successful operation". Table 1. Page 5. [http://www.amtaorg.com/wp-content/uploads/AMTA_Summer06.pdf (Last accessed February 12, 2015)]

membranes. For this reason, a re-evaluation of RO technology for these applications is considered to be warranted.

The proposed treatment schematic for the York River is shown on Figures 7-2 and 7-3. In the proposed scheme, water from the York River would be drawn through wedge wire screens into a raw water pump basin. The intake screens will remove suspended particles greater than a few millimeters in size and prevent the impingement or entrainment of fish and other water fauna.

To remove the relatively high levels of suspended solids and turbidity ahead of the RO system, a robust pretreatment system consisting of coagulation, flocculation and sedimentation followed by either microfiltration (MF) or ultrafiltration (UF) is recommended. In addition to the removal of suspended solids, the MF/UF system will also provide an effective barrier for the removal of water borne pathogens such as *Giardia lamblia*, *Cryptosporidium*, and viruses. Low turbidity feed water from the MF/UF system will be fed to the suction side of the high pressure pumps for the RO system.

The high pressure RO pumps will pressurize the feed water to overcome the osmotic pressure of the feed stream and allow the RO system to extract high purity water from the salt water feed. The operating pressure required by the membranes will increase or decrease in proportion to the salinity and temperature of the feed water. As shown on Figure 7-3, at the average operating condition of 10,000 mg/L of feed and 17 degrees Celsius (63 degrees Fahrenheit), the feed water to the RO membranes will be pressurized to approximately 330 pounds per square inch (psi). At this operating pressure, the RO membranes allow fresh water to flow through the membranes while the majority of the dissolved salts are rejected. As a result, the RO membranes separate the salty river water into a higher purity stream (70 percent of flow) and a more concentrated stream (30 percent of flow). In this manner, the RO process essentially converts a portion of brackish water into a high purity drinking water stream (permeate) and returns the unused portion (concentrate) back to the river. The high purity permeate from the RO system will be passivated through the addition of carbon dioxide and hydrated lime and receive final disinfection in chlorine contact basins prior to storage and distribution. Concentrate from the process will be returned to the river.

Collocating the desalination plant with a power plant or industrial plant that uses once-thru cooling water and discharges reject heat can be cost-effective in terms of reducing energy requirements for the desalination plant as a result of temperature extremes. Direct heating of the feed water to increase temperature to lower operating pressure would probably not be cost-effective.

Pretreatment solids may be discharged back to the river depending on the VPDES discharge limits. As shown on the process flow drawings, a sludge thickener was included for removal of pretreatment solids with supernatent recycle back to the head of the plant. Chlorine can be dosed intermittently at the intake pump station to prevent growth of organisms in the raw water pipelines, pretreatment basins, and MF/UF treatment trains. Chlorine can be neutralized with sodium bisulfite on an assured basis following pretreatment (upstream of the cartridge filters at the RO treatment facility) to ensure that any residual chlorine is removed upstream of the RO membranes and prior to the return of the concentrate to the estuary. Redundant chlorine residual analyzers can be provided to alarm and to shut down the membrane trains in the event that a chlorine residual is detected.

In the RO process, the concentration of salts in the remaining salt water stream or concentrate stream increases as high purity drinking water is removed from the salt water. In this situation, certain salts such as calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate, or silica could become supersaturated near the membrane surface. These supersaturated salts could precipitate and form scale, which is similar to deposits sometimes found in water heaters or water mains. Scale formation is avoided through a combination of adjusting feed water pH, the addition of antiscalant chemical, and the proper selection of the RO system recovery. The scaling potential of the feed water to the RO system is often the limiting factor in determining the system recovery for the RO system.

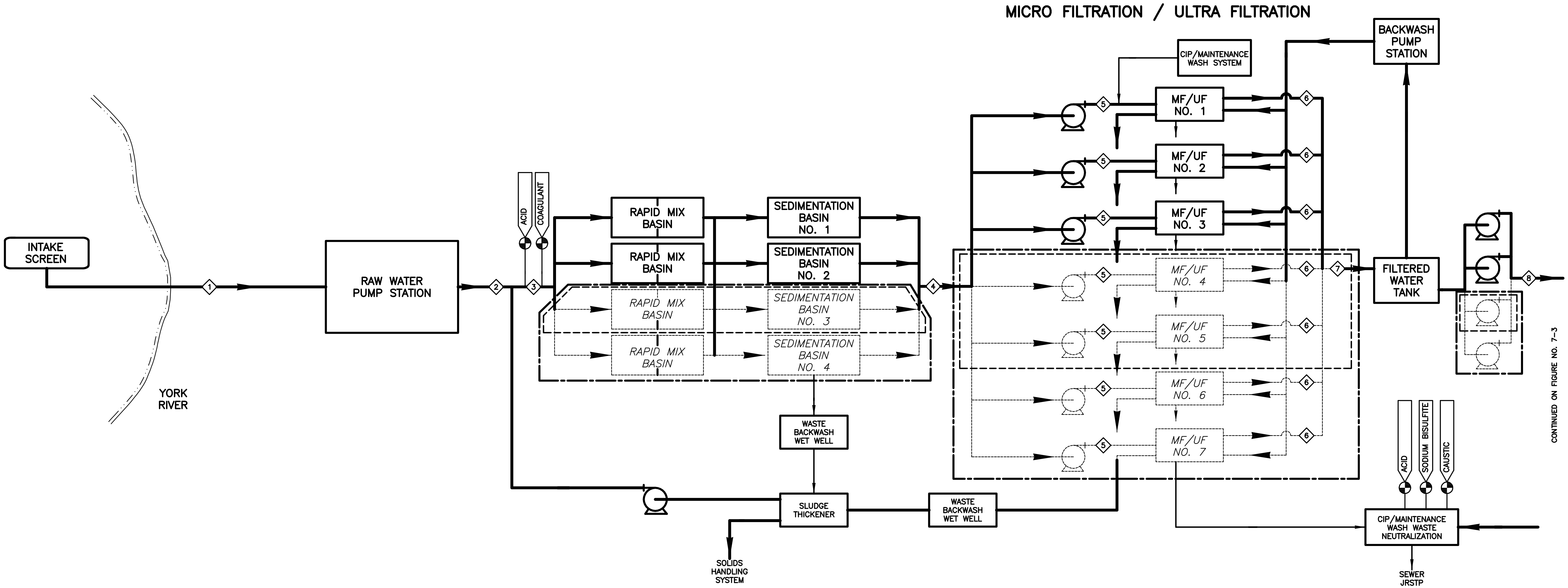
Unfortunately, the raw water data bases that were reviewed to determine the design basis for the RO system did not include sufficient data for the primary ions that are used to determine the scaling potential for an RO system. In this case, the RO system recoveries were selected based on membrane performance parameters including operating pressure, permeate quality, lead element flux, minimum required concentrate flow, etc. If RO is shown to be a cost-effective alternative water supply, it is recommended that a more rigorous analysis of membrane scaling potential and the impact on system recovery be performed.

The RO concentrate needs to be discharged to tidal waters with relatively high salinity levels. Since the RO concentrate consists of natural substances found in the water supply, the only treatment typically required prior to discharge is an air injection system to raise the dissolved oxygen to an acceptable level. However, the actual limits on the discharge concentrations may require dilution and/or diffusers and a mixing zone to stay below the discharge limits.

The required capacity for the treatment facility is highly dependent on the DEQ permitted groundwater withdrawal, the water demand projection, and the amount of water purchased from NNWW. For the purposes of this study, 4-, 8-, and 12-mgd plant capacities were considered. To meet the projected maximum day demand with the existing DEQ Groundwater Withdrawal Permit or revised permit average withdrawal of 7.84 mgd (refer to Tables 3-6 and 3-8), a 4-mgd treatment facility is required prior to 2030 to supplement JCSA's existing water supply without the initial purchase of 2 mgd from NNWW. If DEQ reduces the permitted average groundwater withdrawal to 4 mgd, an 8-mgd facility will be required to meet the 2050 projected demand (refer to Table 3-7). With the initial purchase of 2 mgd from NNWW, a 4-mgd treatment facility would be required prior to 2020 if the Groundwater Withdrawal Permit is reduced to 4.0 mgd. With the existing DEQ Groundwater Withdrawal Permit, the facility will need to be expanded to 12 mgd by 2050 if aggressive growth occurs as reflected in the HRRWSP and additional water is not purchased from NNWW.

The concept for the equipment configuration for the base 4-mgd plant and for expansion to 8-mgd or 12-mgd capacity in the future is shown on the Figures 7-2 and 7-3. This approach assumes that JCSA will want "n+1" redundancy on major process equipment. For the RO units, this translates to three RO units with a production capacity of 2 mgd each. Two units would normally be in operation for full capacity with the third unit serving as an installed standby unit. As shown on Figure 7-3 for the 8-mgd expansion case, two additional 2-mgd units (units 4 and 5) would be added with four units in operation for full capacity with one unit standby. For the 12-mgd capacity, two additional units would be installed above the five units provided for the 8-mgd plant. In this case, six units would be in operation for full production with one standby unit.

A similar expansion strategy could be employed for the MF/UF systems. The capacity of the MF/UF systems are typically five to ten percent higher than the required feed flow to the RO units to account for additional water requirements for backwashing, chemically enhanced backwashes, and maintenance washes.



PROCESS DATA								
	1	2	3	4	5	6	7	8
FLOWS:								
Phase 1 MGD	6.13	6.13	6.13	6.01	3.01	2.86	5.71	5.71
Build-out MGD	18.4	18.4	18.4	18	3.01	2.86	17.14	17.14
CONSTITUENTS:								
TDS, Avg. mg/L	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
TDS, Max. mg/L	16,820	16,820	16,820	16,820	16,820	16,820	16,820	16,820
TSS, Avg. mg/L	58	58	58	12	12	0.5	0.5	0.5
TSS, Max. mg/L								
PRESSURES:								
Avg. psi	atm	45	atm	atm	15	4	4	45
Max. psi	atm	45	atm	atm	35	4	4	45

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
12 - STREAM NUMBER

LEGEND:
---- 8 MGD
-·-·- 12 MGD

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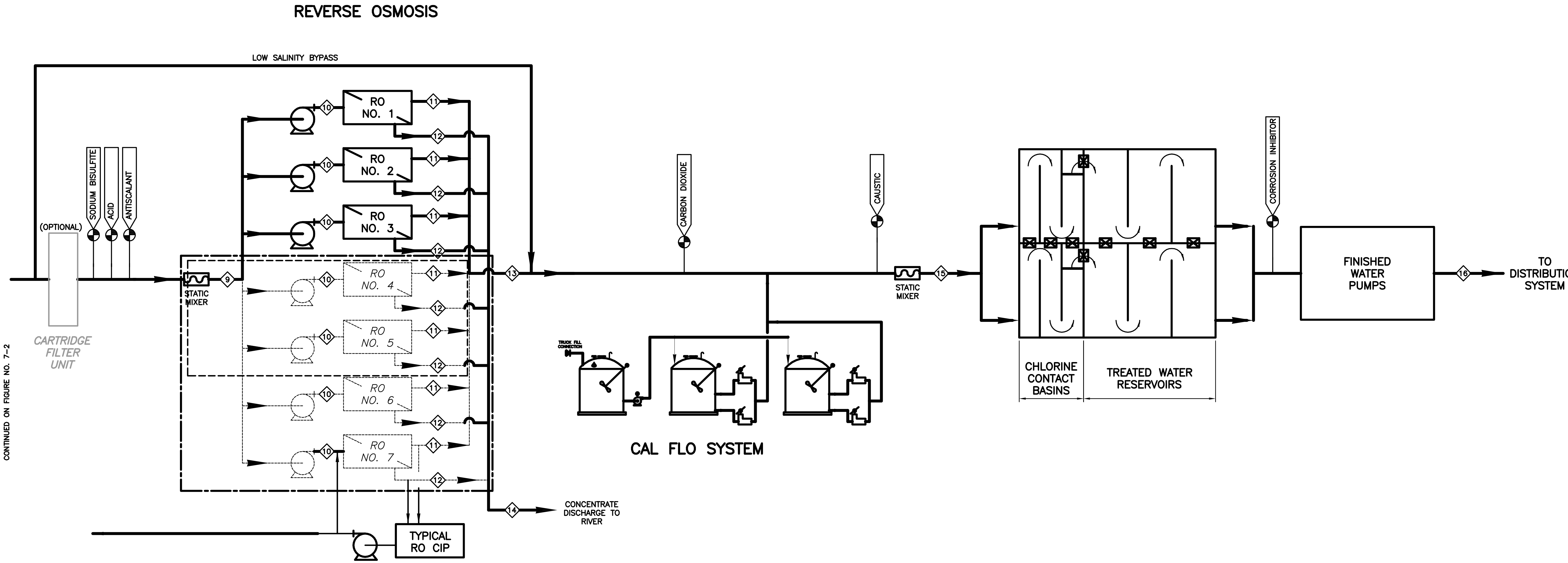
Figure No. 7-2
James City Service Authority
York River Process Flow Diagram I - Clarification and MF/UF



PROCESS DATA	9	10	11	12	13	14	15	16
FLOWS:								
Phase 1 MGD	5.71	2.86	2.0	0.86	4.0	1.71	4.0	4.0
Build-out MGD	17.14	2.80	2.0	0.86	12.0	5.14	12.0	12.0
CONSTITUENTS:								
TDS, Avg. mg/L	10,000	10,000	100	33,140	100	33,140	<200	<200
TDS, Max. mg/L	16,820	16,820	274	55,835	340	55,835	<450	<450
TSS, Avg. mg/L								
TSS, Max. mg/L	0.5	0.5	-	3	-	3	-	-
PRESSURES:								
Avg. psi	30	329	10	465	15	10	8	50
Max. psi	30	599	10	879	15	10	8	50

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
1 AT MAX TDS MIN TEMP
2 AT MAX TDS MAX TEMP
12 - STREAM NUMBER

LEGEND:
- - - - 8 MGD
—·— 12 MGD

CDM Smith

Figure No. 7-3
James City Service Authority
York River Process Flow Diagram II - Desal & Post-Treatment

For the rapid mix and sedimentation basins, the proposed configuration includes two, 100-percent units with one unit capable of treating the required feed flow to two MF/UF units. In this case, if one flocculation/sedimentation train needs to be removed from service, one flocculation/sedimentation train could still provide sufficient flow to the MF/UF units to maintain rated capacity.

There are several potential options for permeate stabilization including carbon dioxide in combination with hydrated lime systems, lime saturators or calcite contactors. A Cal-Flo hydrated lime system is shown on the process flow drawing because it typically is more compact and easier to operate than the other two systems. The concept shown on the drawing would include a storage tank with transfer pump for the base 4-mgd system. This system would also have sufficient capacity for the 8-mgd system without requiring any additional equipment. For expansion to 12 mgd, a second dosing tank would be provided.

Passivated water following carbon dioxide and lime addition is split and flows into two chlorine contact basins. Each chlorine contact basin is configured with three contact channels arranged in series in a serpentine configuration. Finished water from each chlorine contact chamber flows into a treated water reservoir. Depending on the level of redundancy required, the chlorine contact basins and the finished water reservoirs could be arranged in several different configurations. For example, if a standby unit is required for each major process component, then the initial 4-mgd capacity plant could be provided with two chlorine contact basins and two reservoirs as shown in Figure 7-3 with each sized for a 4-mgd capacity plant. In this case, if a chlorine contact chamber or reservoir needs to be taken out of service, the other contact chamber or reservoir could still accommodate full plant capacity. Sizing of the reservoir basins assumes that approximately one million gallons of storage capacity would be provided for a 4-mgd facility. For a plant expansion to 8 mgd, one additional chlorine contact chamber and reservoir could be added to provide the installed standby capacity. For the 12-mgd facility, a total of four chlorine contact basins and reservoirs sized for the 4-mgd capacity case would be provided to cover the design and standby capacity.

The design of the RO system for the York River location, and for the James and Chickahominy River locations (refer to Sections 8 and 9) as well, falls in a range that is generally between brackish and seawater RO designs. Brackish RO membranes typically operate at maximum operating pressures in the range of 400 to 500 psi although the membranes are nominally pressure-rated to 600 psi. Depending on the system recovery and operating temperature range, brackish RO membranes typically treat brackish water up to a concentration of 8,000 to 10,000 mg/L. For high feed water concentrations and higher operating pressures, seawater RO membranes are typically employed.

There are three general categories for seawater RO membranes: higher rejection, low energy, and ultra-low energy. Higher rejection membranes are typically used if the plant owner prefers lower chloride or sodium concentrations than required by federal or state drinking water requirements or if low concentrations of trace constituents such as boron or bromide are required. For feed water with TDS lower than a “typical” seawater concentration of 35,000 mg/L, low energy and ultra-low energy membranes can be used to meet product quality goals at lower power consumption.

For the York River design concept with a maximum feed water salinity of 16.8 ppt, which is almost 50 percent the salt concentration of seawater, a hybrid RO membrane system design consisting of low energy and ultra-low energy consumption seawater RO (SWRO) membranes was developed. This hybrid membrane design will use the higher rejecting low energy membrane to provide sufficiently high salt rejection to produce a product water stream with less than 350 mg/L TDS from 16,800 mg/L feed water at the maximum operating temperature of 28 degrees Celsius, while using the ultra-low energy membranes to provide power savings when operating at the highest operating pressure on 16,800 mg/L feed water at 2 degrees Celsius. At these conditions, the projected feed pressure to the RO system would increase to approximately 600 psi as compared to the 330 psi pressure required for the average feed water conditions of 10,000 mg/L and 17 degrees Celsius.

Since the average feed TDS of 10,000 mg/L is more in the brackish RO (BWRO) TDS range than in the seawater RO range, a two-stage reverse osmosis system operating at 70 percent recovery was proposed. Because of the relatively high recovery, two stage design, and high operating pressure, a turbocharger type energy recovery system is used to recover residual pressure energy from the concentrate stream. The turbocharger recovers pressure energy from the second-stage concentrate leaving the RO process and transfers this energy to the feed to the second-stage of the RO system. For the maximum operating pressure case, the turbocharger will recover pressure energy from the second-stage concentrate stream which will enter the turbine side of the turbocharger at 879 psi and exit at 15 psi to the pump side of the turbocharger which will boost the pressure of the concentrate leaving the first stage of the RO unit from 589 psi and feed it to the second-stage membranes at 893 psi. Without the energy recovery from the turbocharger, the feed pressure to the first stage and overall power consumption of the RO units would be approximately 20 percent higher.

7.5 Physical Infrastructure Impacts

Based on a review of the James City County GIS parcel data base, vacant property appears to be available for the York River water treatment facility northwest of the York River State Park. To feed into the existing water system, it is assumed that approximately 24,000 feet of 36-inch diameter main will be required from an 8-mgd water treatment facility to the existing 16-inch diameter main on Richmond Road. The capacity of the 36-inch diameter would also be adequate for a 12-mgd facility. Additional infrastructure improvements may also be required within the existing system to transmit the flow to the demand centroid. It is recommended that JCSA conduct simulations on their hydraulic water model to define the infrastructure needs for the York River water treatment plant to be hydraulically effective for their system.

7.6 Financial Impacts

Planning-level cost estimates for the York River water treatment facility are presented in Table 7-3. The planning-level cost estimate includes costs to purchase a 7-acre property off Croaker Road. The planning-level cost estimate includes a cost to install a transmission main to connect the WTF to the existing system, but does not include costs for infrastructure improvements necessary to distribute the flow in the system. Planning-level cost estimates were developed for 4-, 8-, and 12-mgd plant capacities. For all capacities, the raw water intake facility, raw water transmission main, and finished water transmission main were assumed to be constructed for the ultimate capacity of 12 mgd.

Annual O&M costs were also developed for an 8-mgd facility. The O&M cost is presented in Table 7-4 and includes costs associated with chemical usage, energy consumption, membrane replacement, sludge disposal, plant waste and concentrate disposal, labor, equipment costs, and repairs. The O&M costs were based on unit costs provided by JCSA for chemical purchase, power, and staffing and planning-level cost estimating guidance provided in the *Desalting Handbook for Planners*.[7]

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[7] Watson, Ian C., O.J. Morin, Jr., and Lisa Henthorne. 2003. *Desalting Handbook for Planners*. U. S. Department of the Interior Bureau of Reclamation, Desalination and Water Purification Research and Development Program Report No. 72.

Table 7-3 Planning-Level Cost Estimate for York River WTF (dollars)

Description	4-mgd Capacity		8-mgd Capacity		12-mgd Capacity	
Intake Facilities						
Intake	14,390,000		14,390,000		14,390,000	
Intake Pump Station	2,140,000		3,210,000		4,170,000	
Raw Water Pipeline	2,610,000		2,610,000		2,610,000	
Instrumentation – Intake Pump Station	610,000		920,000		1,180,000	
Electrical – Intake Pump Station	430,000		650,000		830,000	
Subtotal for Prime Contractor		20,180,000		21,780,000		23,180,000
Construction Contingency		5,050,000		5,450,000		5,800,000
Intake Facilities		25,230,000		27,230,000		28,980,000
Water Treatment Plant						
Yard Piping	1,980,000		2,210,000		2,460,000	
Site	4,770,000		5,680,000		6,590,000	
Pretreatment Basins	2,550,000		3,820,000		5,090,000	
Chemical Systems	3,600,000		4,190,000		4,780,000	
Administration Building	3,060,000		3,060,000		3,060,000	
Process Building	16,790,000		26,710,000		36,630,000	
CCT/Finished Water Storage	1,360,000		1,360,000		1,360,000	
Finished Water Pump Station	2,390,000		3,310,000		4,010,000	
Sludge Processing	1,020,000		1,520,000		2,020,000	
Instrumentation – WTP	1,370,000		1,520,000		1,680,000	
Electrical – WTP	4,900,000		5,830,000		6,770,000	
Concentrate Discharge Main	1,280,000		1,280,000		1,280,000	
Subtotal for Prime Contractor		45,070,000		60,490,000		75,730,000
Construction Contingency		11,270,000		15,120,000		18,930,000
Water Treatment Plant		56,340,000		75,610,000		94,660,000
Transmission Main						
Approximately 24,000 feet of 36-inch diameter main	12,000,000		12,000,000		12,000,000	
Subtotal for Prime Contractor		12,000,000		12,000,000		12,000,000
Construction Contingency		3,000,000		3,000,000		3,000,000
Transmission Main		15,000,000		15,000,000		15,000,000
Total Construction Cost in 2015 dollars	**96,570,000**		**117,840,000**		**138,640,000**	
Engineering, Legal, and Financial Fees	14,490,000		17,680,000		20,800,000	
Pilot Testing	500,000		500,000		500,000	
Permitting	500,000		500,000		500,000	
Land Acquisition (7 acres at $175,000/acre)	1,230,000		1,230,000		1,230,000	
Total Project Costs in 2015 dollars	**$113,290,000**		**$137,750,000**		**$161,670,000**	
Total Project Costs in 2015 dollars per million gallons treated	**$28,322,500**		**$17,218,750**		**$13,472,500**	

Notes:

1. All costs expressed in 2015 dollars.
2. Existing distribution system should be evaluated to determine if the flow will require additional infrastructure improvements.

Table 7-4 Planning-Level O&M Cost Estimate for 8-mgd York River WTF

Description	Annual O&M Cost $
Chemical Usage	1,310,000
Energy Consumption	1,670,000
Sludge Disposal	210,000
Labor	640,000
Equipment Maintenance/Repairs, annualized	1,490,000
Subtotal	5,320,000
Contingency	530,000
Total O&M Cost	5,850,000
	$ 2.00/1000 gal

Note: All costs expressed in 2015 dollars.

7.7 Potential Environmental Concerns

Implementation of the York River water supply and treatment facility may cause the following potential environmental concerns:

- Impact to the 12-mile section of the York River from Almondsville to Plum Point designated as having hydrologic significance described as a "unique segment of sparsely developed, high order tidal river" as listed in the National Park Service, National Rivers Inventory.[8]

- Impact to the York River shellfish management area defined by the Virginia Marine Resources Commission as "public grounds located inshore of a line beginning at the entrance to the Virginia Institute of Marine Science boat basin at Gloucester Point, running Northwesterly to Buoy #30, thence Northwesterly to Buoy #32, thence Northwesterly to Buoy #34, then Northwesterly to Pages Rock Buoy, thence Northwesterly and ending at Clay Bank Wharf.[9]

Other potential environmental concerns that CDM Smith has experienced on RO treatment projects include impingement and entrainment of fish eggs and fish larvae and the impact of the concentrate disposal.

These potential environmental concerns may impact the ability to obtain permits and approval requirements that are identified in Section 11.

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[8] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan*. Page 3-21.

[9] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan*. Page 3-15.

Section 8

James River

The James River flows along the southern boundary of James City County. The James River is the largest river in Virginia, flowing from the Alleghany Mountains southeasterly to Chesapeake Bay at Hampton Roads. The James River Basin encompasses approximately 10,200 square miles.[1] The watershed is divided into three sections: the Upper James (from Alleghany County to Lynchburg), the Middle James (from Lynchburg to the fall line in Richmond), and the Lower James (from the fall line in Richmond to Chesapeake Bay).[2] The Lower James has brackish water influenced by tidal effects.

An investigation of the James River as a potential water supply source for JCSA was conducted based on a review of information from the following sources:

- Buchart Horn, Inc. and Watek Engineering. 2005. *A Brief Feasibility Study, Use of the York or James River for Future Water Supply*.
- Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.*
- Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*.
- Rice, Karen C., Mark R. Bennett, and Jian Shen. USGS Open File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.*
- Rice, Karen C., Bo Hong, and Jian Shen. 2012. "Assessment of salinity intrusion in the James and Chickahominy Rivers as a result of simulated sea-level rise in Chesapeake Bay, East Coast, USA". *Journal of Environmental Management*. Pages 61-69.
- U.S. Environmental Protection Agency. 2014. STORET.
- Virginia Department of Environmental Quality. 2013. *Status of Virginia's Water Resources, A Report on Virginia's Water Resources Management Activities.*

8.1 Existing Withdrawals

8.1.1 Public Water Supplies

Upstream of the tidal section, the James River serves as the primary water supply source for the City of Richmond and Henrico County. The Richmond water treatment plant is designed to produce up to 132 mgd.[3] The Henrico County water treatment facility has a design capacity of 55 mgd and is being

[1] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 3-3.

[2] http://www.jamesriverassociation.org/the-james-river/about-the-james (Last accessed February 10, 2015)

[3] http://www.richmondgov.com/PublicUtilities/WaterQualityReports.aspx (Last accessed February 10, 2015)

upgraded to 80 mgd. The City of Lynchburg also withdraws water from the James River during periods of high demand.

Virginia American Water (VAW) is the water service provider for the City of Hopewell. The VAW water treatment plant in Hopewell withdraws water from the Appomatox River, approximately 1.5 miles upstream of its confluence with the James River. VAW indicated that the intake withdraws water from both rivers due to the tidal influence in this section. The plant has a capacity of 36 mgd, with 18 mgd approved by VDH for potable use and 18 mgd for nonpotable use.[4]

8.1.2 Commercial/Industrial Uses

A summary of existing commercial/industrial withdrawals from the James River is presented in Table 8-1.

Table 8-1 James River Commercial/Industrial Withdrawals[a]

User	Location	2008-2012 Average Withdrawal (mgd)	2012 Withdrawal (mgd)
James River Correctional Center	Goochland County – Beaverdam Creek	0.73	0.64
Honeywell International, Inc.	Hopewell	108.81	110.58
Dupont E. E. DeNemours & Co.	Spruance Plant, Chesterfield County	28.67	30.75
Dominion Generation	Surry Nuclear Plant[b]	1946.5	1938.2
Dominion Generation	Chesterfield Power Station	830.3	681.9
Dominion Generation	Bremo Bluff Power Plant, Fluvanna County	110.0	76.1

Notes:

a. Source: Virginia Department of Environmental Quality. 2013. *Status of Virginia's Water Resources, A Report on Virginia's Water Resources Management Activities*.

b. Water is used for cooling water purposes with most of the water discharged back into the James River.

8.2 Existing VPDES Discharges

A summary of VPDES permitted discharges into the James River between the Chickahominy River confluence and Newport News is presented in Table 8-2 and identified on Figure 8-1.

Table 8-2 VPDES Permitted Discharges to the James River between Chickahominy River and Newport News

Discharger	Location	VPDES Permit No.
BASF Corporation - Williamsburg	James City County	VA0003654
Colonial Pipeline Company - Yorktown	James City County	VA0051870
Colonial Pipeline Surry	Surry	VA0085481
Dominion Yorktown	York County	VA0004103
Grays Creek Marina and Restaurant	Surry	VA0091308
HRSD - Williamsburg STP	James City County	VA0081302
JCSA – FFWTF	Ferry stop at Jamestown	VA0091111

Source: Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan*. Table 3-15 and Map 3-19.

[4] Virginia American Water. 2012. *City of Hopewell Demand Side Management Plan*.

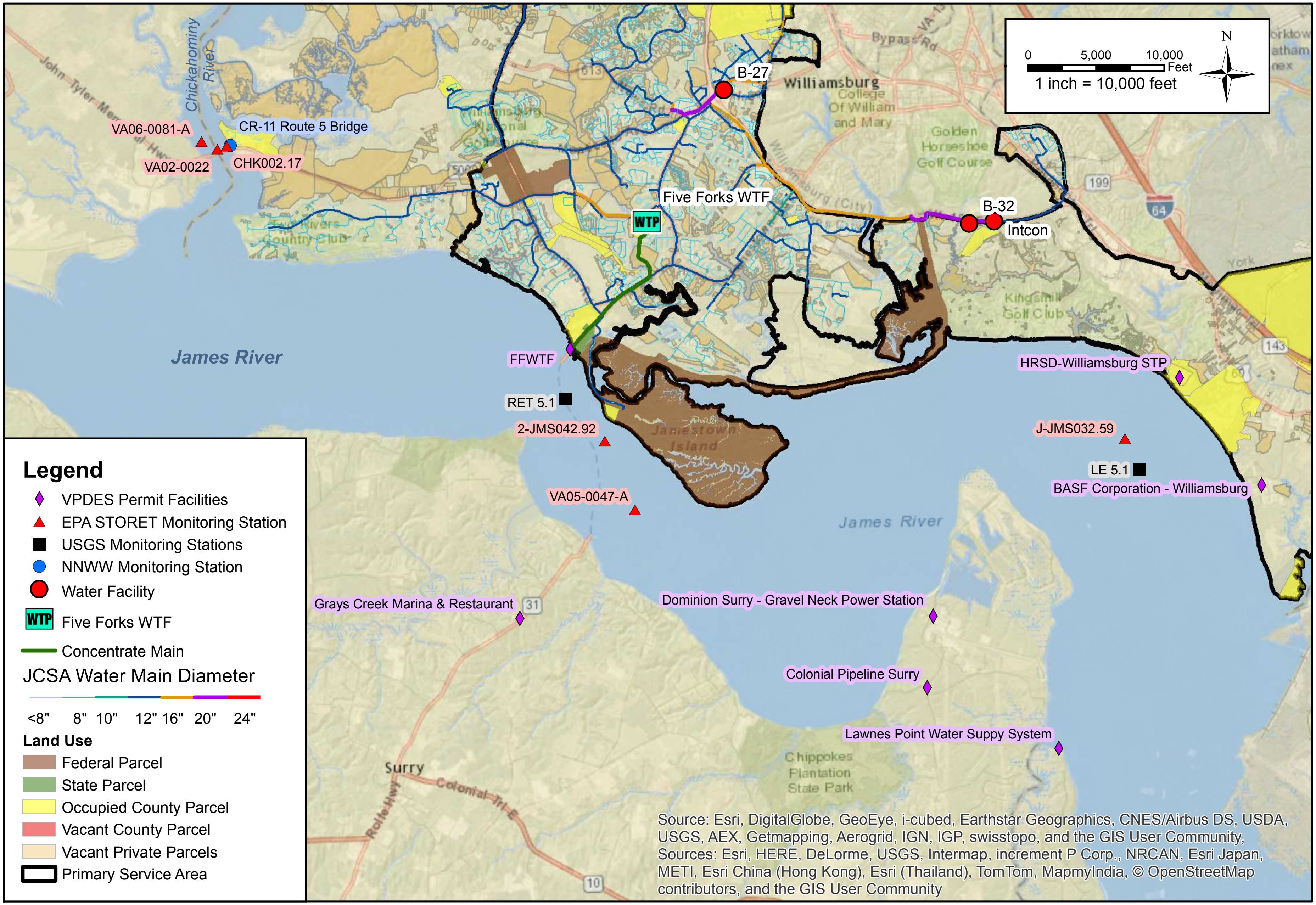

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Figure 8-1
James River
Water Quality Monitoring Stations and VPDES Locations

8.3 Previous Studies

8.3.1 Lower Virginia Peninsula Regional Raw Water Supply Plan EIS

The James River was evaluated as a potential water supply source in the Lower Virginia Peninsula Regional Water Supply Plan EIS. Various alternatives were considered:

- Pumping from a new James River 40-mgd intake in Chesterfield County above Bosher's Dam to headwaters of Diascund Creek Reservoir and then pumping to Little Creek Reservoir (EIS Alternative No. 6)
- Pumping from a new 40-mgd James River intake in Henrico County near Hatcher Island to Diascund Creek Reservoir and then pumping to Little Creek Reservoir (EIS Alternative No. 9)
- Pumping from a new 75-mgd James River intake in Chesterfield County to Diascund Creek Reservoir and then pumping to Ware Creek Reservoir (EIS Alternative No. 12)
- Pumping from a new 75-mgd James River intake in Chesterfield County to Black Creek Reservoir (EIS Alternative No. 14)
- Pumping from a new 70-mgd James River intake in James City County to desalination plant near Waller Mill Reservoir (EIS Alternative No. 24)

A discussion of the alternatives with respect to the proposed intake location follows.

8.3.1.1 Proposed James River Intake in Chesterfield County above Bosher's Dam and in Henrico County near Hatcher Island (EIS Alternative Nos. 6, 9, 12, and 14)

The proposed intake locations on the James River in Chesterfield County above Bosher's Dam and in Henrico County near Hatcher Island involve withdrawals from localities that are not part of the Lower Peninsula regional water supply area and, therefore, would not be benefitting from the withdrawal. The EIS indicated that the Richmond area localities acting through the Richmond Regional Planning District Commission opposed Lower Peninsula withdrawals from the James River above Richmond. Under local and consent laws and provisions in Virginia law, "the governing body (City Council or County Board of Supervisors) of a host locality must grant land use approvals and consents for another locality's development of public water supply facilities within its borders". The EIS also noted that competition for James River water between the City of Richmond and Henrico County could also delay efforts to pursue withdrawals. In addition, VDH expressed strong opposition to withdrawals from the James River between Richmond and Hopewell for public water supply; the EIS did not explicitly state the reasons for the opposition.[5] Alternatives associated with James River withdrawals in Chesterfield County and Henrico County were considered unavailable and impracticable at the time.

8.3.1.2 Proposed James River Intake in James City County (EIS Alternative No. 24)

A 70-mgd raw water intake structure in the James River and pump station was proposed approximately 3,000 feet upstream of Jamestown Ferry Landing. The raw water would be transported through 9 miles of dual 36-inch diameter mains to a 44-mgd RO facility located near Waller Mill Reservoir. The raw water and treatment facility capacities assumed a recovery rate of 60 percent and 10 percent RO module bypass. The concentrate would be discharged back into the James

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[5] Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*. Page 3-60.

River through 20 miles of 36-inch diameter pipeline. A treated water safe yield benefit of 30 mgd was estimated for this alternative, assuming no minimum instream flow (MIF) requirement.

Construction of a 60-mgd raw water intake in the James River and pump station was also considered at Sturgeon Point in Charles City County. The raw water would be transported through 21.5 miles of dual 36-inch diameter pipe to a 44-mgd electrodialysis reversal (EDR) desalting facility. The concentrate would be discharged through 20 miles of 24-inch diameter main. The raw water and treatment capacities assume a recovery rate of 75 percent. A treated water safe yield of 30 mgd was estimated for this alternative, assuming no MIF requirement.

The EIS indicates that the proposed Jamestown intake would be located at the lower end of the turbidity maximum zone of the Lower James River estuary. The turbidity maximum zone has widely fluctuating salinity levels.

The presence of kepone in the James River was identified as a potential concern; the pesticide was discharged into the river in the early 1970s and trapped in the bottom sediments of this segment of the river. The impact of the construction of the intake and channel dredging has unknown effects. At the time, VDH had strong opposition to the use of the James River below Hopewell as a public water supply source.

As stated in the EIS, the James River was considered technologically and economically infeasible as a regional water supply source due to raw water quality variability, particularly fluctuating salinity levels, and treatment control concerns that questioned reliability. However, since the time that the EIS was completed in 1997, technological advancements have occurred that allow RO systems to cope better with fluctuations in salinity levels and make RO technology a more viable option for treating the James River today.

8.3.2 Brief Feasibility Study for JCSA Future Water Supply (2005)

A brief feasibility study of the James River as a future water supply for JCSA was completed in November 2005 by Buchart Horn, Inc. and Watek Engineering Corporation. JCSA indicated that the study focused on the York River due to potential issues associated with the James River that included shore space availability for an intake, hydraulic issues to move the water through the system, potential negative perception of the discharge of the Dominion Surry Nuclear Power Plant and the HRSD Williamsburg sewage treatment plant, and fluctuating raw water quality.

8.4 Evaluation of Treatment Options

8.4.1 Water Quality Evaluation

Figure 8-1 identifies the location of the FFWTF concentrate main that discharges into the James River. For the purpose of this study, it is assumed that the proposed raw water intake would be located off the County-owned property west of the concentrate discharge main shown on Figure 8-1. Water quality data from the following sources were reviewed to determine treatment requirements:

- U.S. Environmental Protection Agency. 2014. STORET.
- Rice, Karen C., Mark R. Bennett, and Jian Shen. USGS Open File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.*

- Rice, Karen C., Bo Hong, and Jian Shen. 2012. "Assessment of salinity intrusion in the James and Chickahominy Rivers as a result of simulated sea-level rise in Chesapeake Bay, East Coast, USA". *Journal of Environmental Management*. Pages 61-69.

Based on a review of the EPA STORET database, DEQ Water Quality Monitoring Station 2-JMS042.92 on the James River at Swann Point was identified as the closest monitoring point. Intermittent sampling was conducted at this station from March 15, 2005 to December 5, 2013. A summary of the available pertinent water quality data is provided in Appendix A. Water quality data from DEQ Monitoring Station 2-JMS032.59 which is located further downstream at Red Buoy M36 on the James River and data from EPA monitoring station VA05-0047-A is also included in Appendix A for comparative purposes. The locations of these monitoring points are shown on Figure 8-1.

USGS Open-File Report 2011-1191, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay,* provides salinity data for the James River. The closest water quality monitoring station to the proposed James River intake is RET5.1 which is 62.8 km (39 mi) upstream of the mouth of the river. The salinity data provided from January 1985 to August 2014 is presented in Figure 8-2; approximately two salinity data results were reported each month. The maximum salinity during this time period was 12.5 ppt, which occurred during 2002. The average salinity for the sample values was 2.5 ppt.

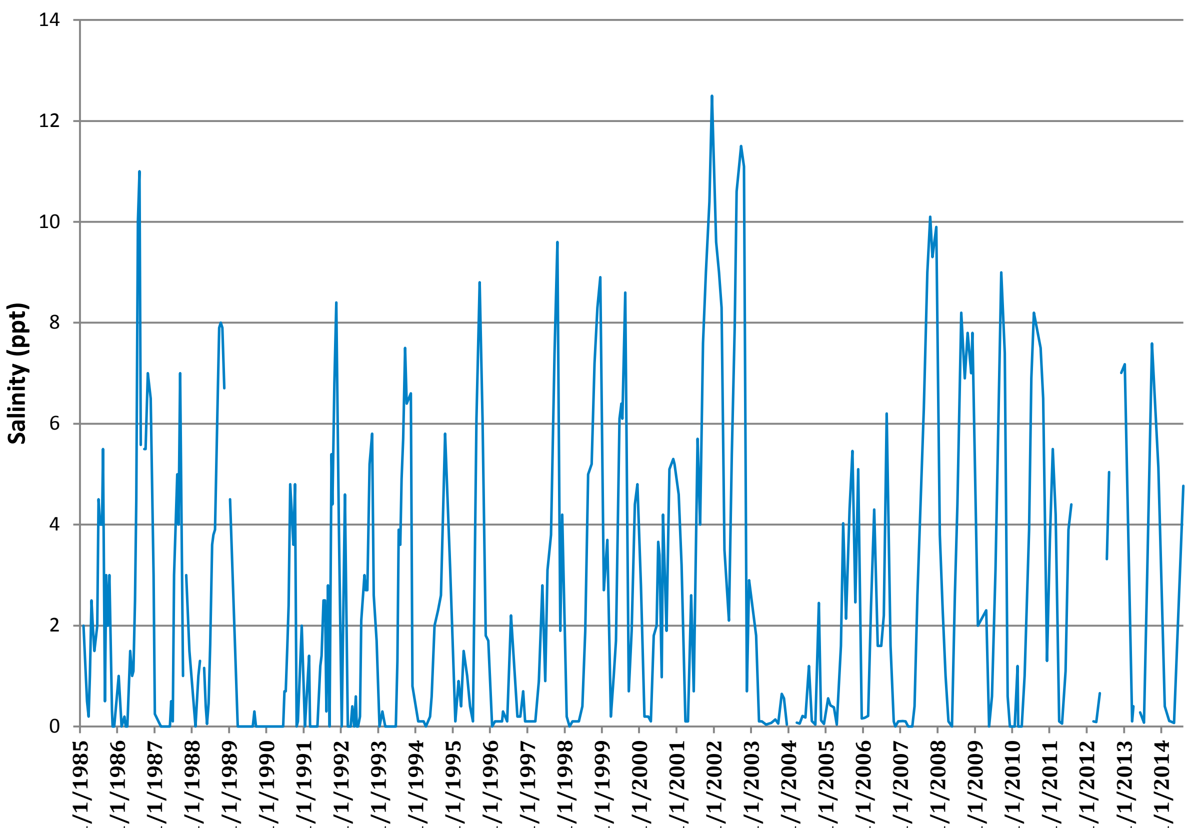


Figure 8-2
Salinity Data for USGS Water Quality Monitoring Station RET5.1

Based on data provided by K. C. Rice, et al. (2012), the maximum and average salinity at monitoring station LET5.1, approximately 48.1 km (30 mi) upstream of the mouth of the river, is estimated to be 11.9 ppt and 5.5 ppt, respectively, for 2005 which was identified as a typical year. The average salinity of LET5.1 is closer to the average salinity values reported in Appendix A for the EPA and DEQ monitoring stations than the average salinity estimated for RET5.1. For the purposes of this study, a maximum salinity of 12.5 ppt and an average salinity of 5.6 ppt were assumed for the James River intake site.

8.4.2 Recommended Treatment

Based on the water quality evaluation results, RO treatment is recommended for the James River. The proposed treatment schematic is shown on Figures 8-3 and 8-4. The capacity and treatment process requirements for the James River are similar to the capacity and treatment process discussed in Section 7.4.2 for the York River. The footprint of an 8-mgd treatment facility is estimated to require approximately 7 acres. JCSA indicated that the existing FFWTF site does not have sufficient area for the James River RO facility; adjacent property is not available. JCSA noted that available property suitable for the facility in close proximity to the river is limited since most of the area is developed or protected from development (e.g. historic preservation,); potential available property has not been identified at this time.

The existing concentrate discharge main from the FFWTF runs southeast of the plant, north of Powhatan Creek, then southward, parallel to Jamestown Road, discharging into the James River. Between the FFWTF and Jamestown Road, the concentrate discharge main is located centered on a 20-foot permanent easement. A second concentrate discharge main will also be required for the James River RO facility. The feasibility of using the existing outfall should be evaluated during design to reduce environmental impacts. It is recommended that the raw water intake be located at least 1,500 feet upstream of the concentrate discharge point.

The raw water intake may be located off the County-owned property along the James River, northwest of the Jamestown Road/Greensprings Road intersection if it is in within reasonable distance of the available property. The raw water main may be installed parallel to the concentrate main from Jamestown Road to the FFWTF if it is along the path to the available property. However, it should be noted that the Jamestown Beach area of the James River is heavily used by swimming, boating, and other water activities; this area is also shallow, ranging from 4 to 10 feet in depth for hundreds of feet off the shore depending on tidal influences.

As noted above, the treatment scheme for the James River treatment facility is basically similar to the proposed scheme for the York River; however, due to the lower maximum feed TDS of 12,500 mg/L, there are a few differences in the design concept for the RO system. For the York River option, with a maximum feed TDS of approximately 16,800 mg/L, a hybrid membrane array of low energy SWC5 and ultra-low energy SWC6 membranes is proposed. This membrane configuration was selected to achieve a finished water TDS of <350 mg/l based on the worst case design condition of 16,800 mg/l feed TDS and a temperature of 28 degrees Celsius. The 350 mg/l TDS figure was listed as a JCSA finished water quality goal in an article on the FFWTF.[6]

[6] Movahed, Ben, "Five Forks RO plant in Virginia after 1 year of successful operation" American Membrane Technology Association. 2006. New Facilities Solutions. Table 1. Page 5. (http://www.amtaorg.com/wp-content/uploads/AMTA_Summer06.pdf (Last accessed February 12, 2015)

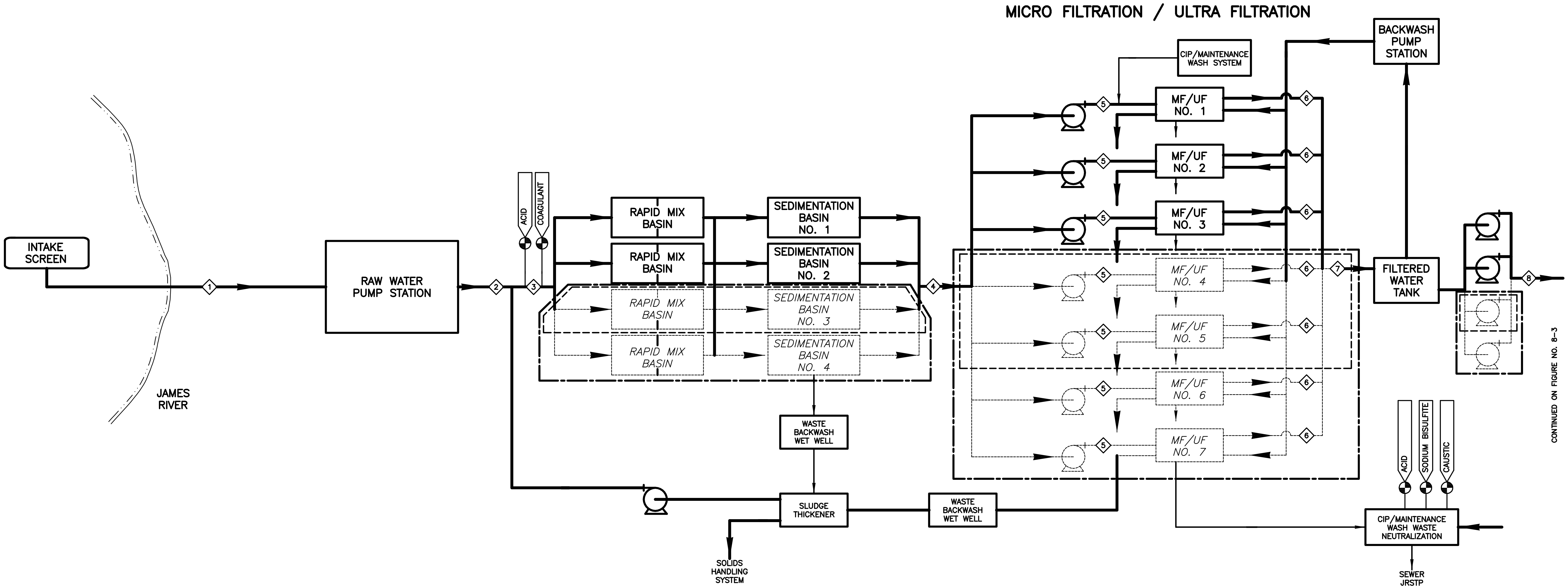
For the James River location, with a maximum feed TDS of 12,500 mg/L, an RO system consisting of all ultra-low energy SWCY membranes can be used and still achieve the JCSA finished water quality goal of 350 mg/L TDS. An all ultra-low energy membrane configuration could also be used for the York River design if a maximum finished water TDS in the range of 400 to 450 mg/L would be considered acceptable. In the York River case, since the feed TDS is over 15,000 mg/L, the operating flux (amount of permeate produced per square foot of RO membrane area) was set at 8 gallons/square foot/day (gfd), which is a typical design flux for a seawater RO plant. For the James River option with a feed TDS less than 15,000 mg/L, the design flux for the membrane system was set at 12 gfd, which is a typical operating flux for a brackish RO surface water treatment plant.

For the York River case, the membrane array for a 2-mgd RO treatment unit consists of a first stage with 60 vessels with seven RO elements per vessel and a second stage of 30 vessels with seven elements per vessel. In comparison, the James River design operating at a higher flux rate of 12 gfd only requires 40 vessels with seven elements/vessel in the first stage and 20 vessels with seven elements/vessel in the second stage.

In general, the feed pressure to produce a given RO permeate flow rate increases in proportion to the feed TDS to the RO unit. However, operating at a higher flux also tends to increase the required feed pressure to the RO unit. In comparing the maximum operating pressure for the York River RO plant of 599 psi on Figure 7-3 with the maximum operating pressure for the James River RO plant of 639 psi on Figure 8-4, operating at a higher flux rate is one of the primary factors that causes the operating pressure of the James River RO plant to be higher than the York plant even though the feed TDS for the James River plant is lower.

For the actual design of these facilities, a more rigorous evaluation would be performed to optimize system flux versus life cycle cost. In general adjusting the number of RO membranes in the system changes the operating flux and changes the balance between capital and operating costs. Increasing the number of RO membranes in a system will lower the operating flux and reduce the system operating pressure and power consumption which reduces operating costs. However, adding RO membranes to the system increases the system capital cost. Conversely, decreasing the number of membranes in the system increases the operating flux which increases the operating pressure and the system operating costs, but lowers the capital cost of the system. During the detailed design of the system an analysis can be performed to determine the optimum number of membranes and operating flux that results in the optimum balance of capital versus operating costs that would result in the lowest overall life cycle cost. In this case, it is estimated that changing operating flux from 8 gfd to 12 gfd would result in an increase in power consumption of approximately 3 percent.

Another contributing factor in increasing the feed pressure of the James River plant is the 75-percent system recovery for this plant compared to 70-percent recovery for the York River plant. The system recovery for the James River plant was increased due to the lower feed TDS. Increasing the system recovery reduces the withdrawal rate of water from the river by about 2.4 mgd for the James River versus the York River for the 12-mgd capacity facility. Similarly, operating at 75-percent recovery reduces the concentrate discharge for the James River plant by 1.14 mgd or 22 percent versus the York River plant.



PROCESS DATA

	1	2	3	4	5	6	7	8
FLOWS:								
Phase 1 MGD	5.72	5.72	5.72	5.61	2.81	2.67	5.33	5.33
Build-out MGD	17.17	17.17	17.17	16.84	2.81	2.67	16.0	16.0
CONSTITUENTS:								
TDS, Avg. mg/L	5,600	5,600	5,600	5,600	5,600	5,600	5,600	5,600
TDS, Max. mg/L	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
TSS, Avg. mg/L	58	58	58	12	12	0.5	0.5	0.5
TSS, Max. mg/L								
PRESSURES:								
Avg. psi	atm	45	atm	atm	15	4	4	45
Max. psi	atm	45	atm	atm	35	4	4	45

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
12 - STREAM NUMBER

LEGEND:

---- 8 MGD
—-— 12 MGD

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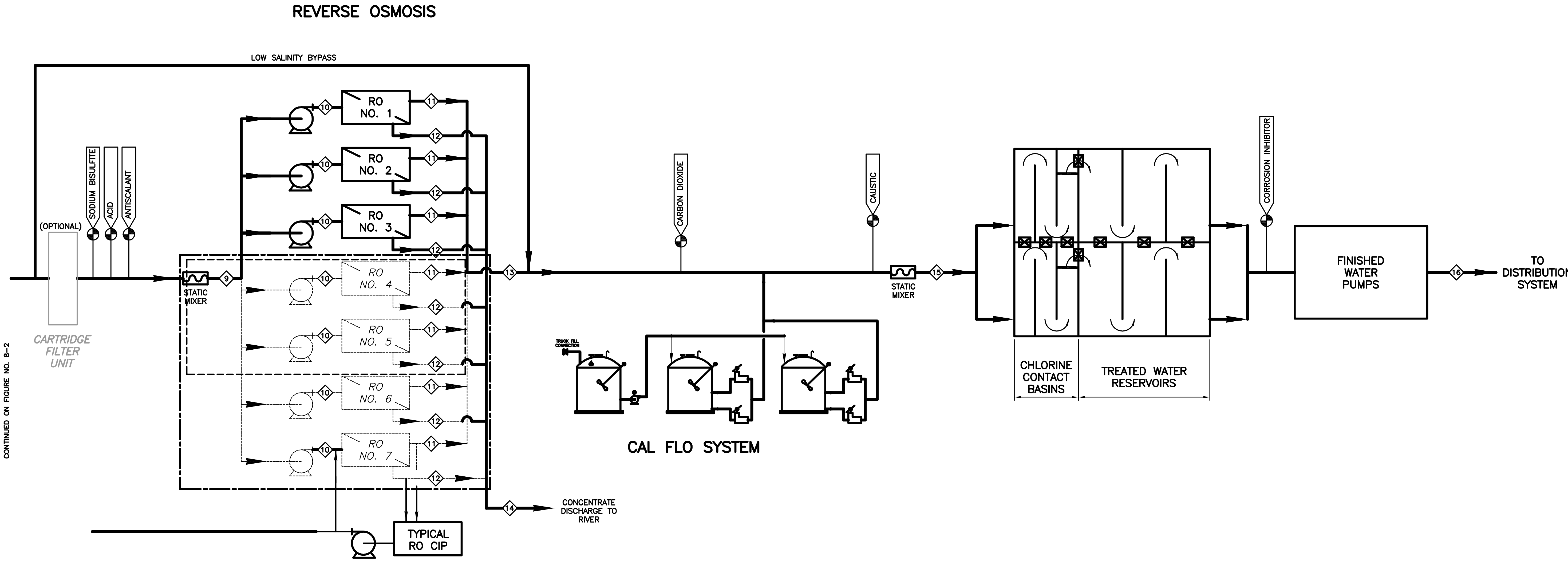
Figure No. 8-3
James City Service Authority
James River Process Flow Diagram I - Clarification and MF/UF



PROCESS DATA

	9	10	11	12	13	14	15	16
FLOWS:								
Phase 1 MGD	5.33	2.67	2.0	0.67	4.0	1.33	4.0	4.0
Build-out MGD	16.0	2.67	2.0	0.67	12.0	4.0	12.0	12.0
CONSTITUENTS:								
TDS, Avg. mg/L	5,600	5,600	52	22,280	52	22,280	<120	<120
TDS, Max. mg/L	12,500	12,520	193	49830	193	49830	<250	<250
TSS, Avg. mg/L								
TSS, Max. mg/L	0.5	0.5	-	3	-	3	-	-
PRESSURES:								
Avg. psi	30	316	10	415	15	10	8	50
Max. psi	30	639	10	903	15	10	8	50

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
1 AT MAX TDS MIN TEMP
2 AT MAX TDS MAX TEMP
12 - STREAM NUMBER

LEGEND:
8 MGD
12 MGD

CDM Smith

Figure No. 8-4
James City Service Authority
James River Process Flow Diagram II - Desal & Post-Treatment

As a result of the higher operating flux and reduced number of RO membranes and vessels for the James River plant, the foot print of the RO units and the membrane process building will be reduced by approximately 500 to 600 square feet for a 12-mgd facility.

8.5 Physical Infrastructure Impacts

Physical infrastructure improvements within the existing water system will be required to distribute the flow from the water treatment facility site to the demand centroid. It is recommended that JCSA conduct simulations on their hydraulic water model to define the infrastructure needs once potential property has been identified.

8.6 Financial Impacts

Planning-level cost estimates for the James River water treatment facility are presented in Table 8-3. The planning-level cost estimate includes costs to purchase a 7-acre property which has not been identified by JCSA at this time. The planning-level cost estimates for infrastructure improvements necessary to transport water from the James River to the treatment facility, distribute the finished water in the system, and dispose of the concentrate are dependent on the location of the proposed water treatment facility. As an initial cursory estimate, the average cost of the raw water transmission main and concentrate discharge main estimated for the York River and Chickahominy River options was assumed for the James River alternative. For the finished water transmission main, it was assumed that the James River WTF would be located closer to a large existing transmission main and that the unit cost would be higher since it would be constructed in a developed area. The planning-level level cost estimates should be refined once potential property has been identified.

Planning-level O&M costs are presented in Table 8-4. The O&M costs were developed in a similar manner as the O&M costs for the York River discussed in Section 7.6.

8.7 Potential Environmental Concerns

Implementation of the James River water supply option may cause the following potential environmental concerns:

- Impact to tidal bald cypress forests and woodlands along James River near Swanns Point, Surry County, as identified in the Virginia Department of Conservation and Recreation, Natural Heritage Inventory (defined as "habitat of rare, threatened, or endangered plant and animal species, rate or state significant natural communities or geologic sites, and similar features of scientific interest").[7]
- Impact to the 62-mile stretch of James River from Hopewell to Mogarts Beach designated as historic. The National Rivers Inventory describes it as "one of the most significant historic, relatively undeveloped rivers in the entire northeast region. Within or adjacent to the corridor are four National Historic Register Sites and one National Historic Park."[8]

[7] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page3-14.

[8] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Table 3-9.

- Impact to the 25-mile segment of James River from 1.2 miles east of Trees Point to Lawnes Creek designated as a Scenic River by Virginia Department of Conservation and Recreation.[9]

The potential impact of the following environmental factors may also be of concern to the public:

- Presence of kepone, a pesticide that was discharged upstream in the 1970s and trapped in the bottom sediments of the river
- VPDES discharges in the vicinity of the intake
- Potential spill upstream from major highway/railway crossings such as the oil spill in Lynchburg in April 2014[10]

These potential environmental concerns may impact the ability to obtain permits and approval requirements that are identified in Section 11.

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[9] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Table 3-7.

[10] http://www.wset.com/story/25397260/cleanup-begins-after-crude-oil-spills-into-james-river-in-train-derailment

Table 8-3 Planning-Level Cost Estimate for James River WTF (dollars)

Description	4-mgd Capacity	8-mgd Capacity	12-mgd Capacity
Intake Facilities			
Intake	13,450,000	13,450,000	13,450,000
Intake Pump Station	2,000,000	3,000,000	3,900,000
Raw Water Pipeline[3]	2,500,000	2,500,000	2,500,000
Instrumentation – Intake Pump Station	570,000	860,000	1,100,000
Electrical – Intake Pump Station	400,000	610,000	780,000
Subtotal for Prime Contractor	18,920,000	20,420,000	21,730,000
Construction Contingency	4,730,000	5,110,000	5,430,000
Intake Facilities	23,650,000	25,530,000	27,160,000
Water Treatment Plant			
Yard Piping	1,850,000	2,070,000	2,300,000
Site	4,460,000	5,310,000	6,160,000
Pretreatment Basins	2,380,000	3,570,000	4,760,000
Chemical Systems	3,480,000	4,050,000	4,620,000
Administration Building	3,060,000	3,060,000	3,060,000
Process Building	15,480,000	24,510,000	33,540,000
CCT/Finished Water Storage	1,270,000	1,270,000	1,270,000
Finished Water Pump Station	2,230,000	3,310,000	4,010,000
Sludge Processing	950,000	1,420,000	1,890,000
Instrumentation – WTP	1,280,000	1,420,000	1,570,000
Electrical – WTP	4,900,000	5,830,000	6,770,000
Concentrate Discharge Main	1,300,000	1,300,000	1,300,000
Subtotal for Prime Contractor	42,640,000	57,120,000	71,250,000
Construction Contingency	10,660,000	14,280,000	17,810,000
Water Treatment Plant	53,300,000	71,400,000	89,060,000
Transmission Main[3]			
Approximately 5,300 feet of 36-inch diameter main	5,000,000	5,000,000	5,000,000
Subtotal for Prime Contractor	5,000,000	5,000,000	5,000,000
Construction Contingency	1,250,000	1,250,000	1,250,000
Transmission Main	6,250,000	6,250,000	6,250,000
Total Construction Cost in 2015 dollars	**83,200,000**	**103,180,000**	**122,470,000**
Engineering, Legal, and Financial Fees	12,480,000	15,480,000	18,370,000
Pilot Testing	500,000	500,000	500,000
Permitting	500,000	500,000	500,000
Land Acquisition (7 acres at $325,000/acre)	2,280,000	2,280,000	2,280,000
Total Project Costs in 2015 dollars	**$98,960,000**	**$121,940,000**	**$144,120,000**
Total Project Costs in 2015 dollars per million gallons treated	**$24,740,000**	**$15,242,500**	**$12,010,000**

Notes:
1. All costs expressed in 2015 dollars.
2. Existing distribution system should be evaluated to determine if the flow will require additional infrastructure improvements.
3. Refine costs once property location has been identified.

Table 8-4 Planning-Level O&M Cost Estimate for 8-mgd James River WTF

Description	Annual O&M Cost $
Chemical Usage	1,250,000
Energy Consumption	1,580,000
Sludge Disposal	210,000
Labor	640,000
Equipment Maintenance/Repairs, annualized	1,320,000
Subtotal	5,000,000
Contingency	500,000
Total O&M Cost	5,500,000
	$1.88/1000 gallons

Note: All costs expressed in 2015 dollars.

Section 9
Chickahominy River

The Chickahominy River flows along the northwestern boundary of James City County and feeds into the James River along the southern boundary. An investigation of the Chickahominy River as a potential water supply source for JCSA was conducted based on information from the following sources:

- Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.*
- Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*.
- Rice, K.C., Bennett, M.R., and Shen, J. 2011. *Simulated changes in salinity in the York and Chickahominy Rivers from projected sea-level rise in Chesapeake Bay: U.S. Geological Survey Open-File Report 2011–1191*, 31 p.
- U.S. Environmental Protection Agency, STORET database.
- Virginia Department of Environmental Quality. 2013. *Status of Virginia's Water Resources, A Report on Virginia's Water Resources Management Activities.*

9.1 Existing Withdrawals

The Chickahominy River provides approximately 70 percent of the water supply for NNWW.[1] In 1942, Walker's Dam was constructed on the Chickahominy River to form an impoundment to supply drinking water for military personnel. The impoundment, which is known as Chickahominy Lake, was purchased by Newport News. The raw water intake is located above Walker's Dam. Water is pumped from the Chickahominy River above Walker's Dam into reservoirs: Lee Hall and/or Harwood's Mill, Little Creek, Skiffes Creek, Waller Mill or Big Bethel. NNWW also uses groundwater as a secondary source. The surface water and groundwater are treated separately and then combined prior to distribution.

The Chickahominy River intake of NNWW has a drainage area of 301 square miles and an average river flow of 180 mgd. A minimum flow of 10 cfs (6.5 mgd) must be maintained downstream of Walker's Dam.[2] NNWW maintains the 10-cfs MIF requirement by controlling the openings in the dam through SCADA.

NNWW's surface water withdrawal permit restricts pumping when the river stage at Walker's Dam is below elevation 3 feet mean sea level. NNWW indicated that the pumping restriction is tied to their Little Creek Reservoir permit; they are not allowed to pump to Little Creek Reservoir when the river is below that level. To avoid drawing high chloride water, withdrawals may also be suspended when tidal influences occur and downstream chlorides are elevated, such as during drought conditions.[3] NNWW

[1] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 6-4.

[2] Norfolk District Army Corps of Engineers. 1997. *Final Environmental Impact Statement (EIS), Main Report - Volume I, Regional Raw Water Study Group Lower Virginia Peninsula Regional Raw Water Supply Plan*. Page 2-3.

[3] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 1-6.

indicated that the withdrawal suspension is not stipulated in a permit, but is part of their operational strategy to stay within the treatment capabilities of their plant. Raw water from the Chickahominy River is sometimes blended with the reservoir waters to reduce the chloride concentration. During the 2002 drought, NNWW had to suspend withdrawal from the Chickahominy River on some occasions.

9.2 Existing VPDES Discharge

The Hideaway Sewage Treatment Plant in Mount Airy discharges into the Chickahominy River as regulated by VPDES Permit No. VA0080233.[4] The discharge location is shown on Figure 9-1.

9.3 Previous Studies

The Chickahominy River was evaluated as a potential water supply source in the Lower Virginia Water Supply Plan EIS through increased withdrawals. Three alternatives were considered:

- Increase in Chickahominy River pump station capacity from 61 to 81 mgd (EIS Alternative No. 11) - An expansion of NNWW's Walker pump station to 81 mgd was considered when pumping to Little Creek and/or Ware Creek reservoirs. The Walker pump station is located on the northern bank of the river in southeastern New Kent County. Approximately 41 mgd would be discharged 7.5 miles downstream to Little Creek Reservoir in James City County and 40 mgd would flow 1.8 miles further to Ware Creek Reservoir. Flow would only go to NNWW's terminal reservoirs if Ware Creek and Little Creek reservoirs are full and at a lower rate. The diversion would require 1.5 miles of pipe from the existing NNWW raw water main to Ware Creek reservoir and replacement or parallel installation of a portion of the old Chickahominy main from the Walkers pump station to Little Creek outfall.

- Increase in Chickahominy River pump station capacity to 61 mgd when pumping to Little Creek Reservoir only (EIS Alternative No. 17) - An expansion of NNWW's Walker pump station to 61 mgd was also considered when pumping to Little Creek and/or Ware Creek reservoirs. The flow from Chickahominy River would be pumped to either Little Creek or Ware Creek reservoirs and no flow would be transferred directly to the terminal reservoir when 61 mgd is discharged to Little Creek and/or Ware Creek reservoir.

- Increase in Chickahominy River pump station capacity to 61 mgd and raise Diascund and Little Creek Dams (EIS Alternative No. 18).

The EIS concluded that increasing the withdrawal from the Chickahominy River to 61 mgd or greater was infeasible for the following reasons:

- Increases in the maximum withdrawal from the Chickahominy River would likely trigger more restrictive MIF requirements above the current 10-cfs requirement.

- Reliance on the single river source that is already a major water supply for the Lower Peninsula would not be prudent and would not provide a backup source should water quality excursions or extreme low flows limit the withdrawal.

- Increasing the withdrawal to 61 mgd would raise the maximum withdrawal to 30 percent of average streamflow at the intake.

[4] http://watersgeo.epa.gov/mwm/(Last accessed November 13, 2014)

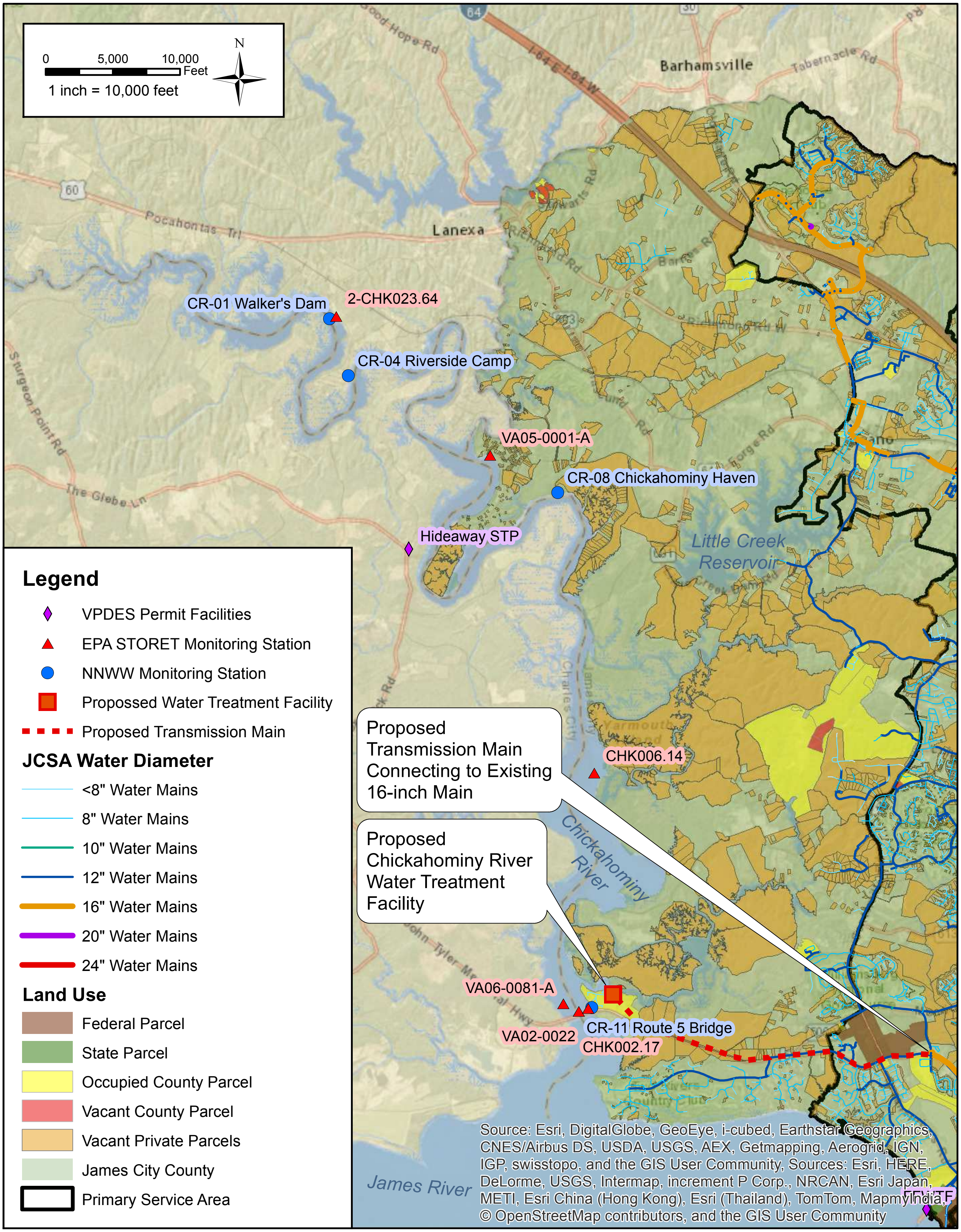

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Figure 9-1
Chickahominy River
Potential Water Supply Source

9.4 Evaluation of Treatment Options

9.4.1 Water Quality Evaluation

The location of a raw water intake in the freshwater section of the Chickahominy River upstream of Walker's Dam would be outside the boundary of James City County. Hence, for the purpose of this study, it is assumed that the raw water intake is located in the brackish section of the Chickahominy River downstream of Walker's Dam. Also, it is assumed that the raw water intake would be located off County-owned property along the Chickahominy River, north of the Route 5 Bridge (i.e. James City County Chickahominy River Front Park). This location is near the Chickahominy River's confluence with the James River.

Water quality data from the following sources were reviewed to determine treatment requirements:

- NNWW historical raw water quality data for the Chickahominy River
- U.S. Environmental Protection Agency. 2014. STORET
- Rice, Karen C., Mark R. Bennett, and Jian Shen. *USGS Open File Report 2011-1191*, *Simulated Changes in Salinity in the York and Chickahominy Rivers from Projected Sea-Level Rise in Chesapeake Bay.*

A summary of the available water quality data from the NNWW monitoring stations is presented in Tables 9-1. Water quality data for CR-1 which is located upstream of Walker's Dam is also provided in Appendix B, Table B-1. Data from the DEQ and EPA monitoring stations is provided in Appendix B, Table B-2. The location of the monitoring stations is shown on Figure 9-1.

Table 9-1 Chloride and Conductivity for NNWW Chickahominy River Monitoring Stations (1997-2014)

Monitoring Station	Chloride (mg/L)			Conductivity (x1000, uS/cm)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
CR-1	4	1600	53	0.05	7.02	0.25
CR-4	4	2200	88	0.05	7.70	0.36
CR-8	8	3620	493	0.06	10.96	1.73
CR-11	10	4600	824	0.05	13.85	2.82

NNWW monitoring station CR-11 is located at the proposed raw water intake location. Hence, the chloride and conductivity values were assumed to establish the Chickahominy River treatment requirements.

CDM Smith conducted pilot testing for the Haverstraw RO treatment facility which draws water from the Hudson River. The pilot test results indicated that a chloride concentration of 4,600 mg/L (the maximum value observed at NNWW monitoring station CR-11 as listed in Table 9-1) corresponds with a total dissolved solids (TDS) concentration of 8,800 mg/L. The average chloride concentration of 824 mg/L corresponds with a TDS concentration of 1,650 mg/L. In developing the design concept for the RO facility for this site, the following design criteria were employed:

- Maximum TDS of 8,800 mg/L and average TDS of 1,700 mg/L
- Temperature range of 2 to 28 degrees Celsius (36 to 82 degrees Fahrenheit)

- Total suspended solids (TSS) concentrations similar to the York River and James River sites

It is interesting to note that the average feed TDS concentration of 1,700 mg/L is only about 20 percent of the maximum feed TDS of 8,800 mg/L for the Chickahominy River in contrast to the James and York River sites where the ratios of average to maximum feed TDS values are 45 percent and 60 percent, respectively. It was anticipated that the data base on chloride concentrations collected by NNWW that includes over 450 data points covering a 17-year period would give a fairly accurate average chloride concentration value; however, in reviewing the data again, there does appear to be a disproportionately higher number of readings in 2003 and 2004 which have low chloride values that may be skewing the average; the reason for the higher number of readings is unknown. The concern is that if there is a very large difference between the average feed TDS and the maximum TDS, as in this case where the average TDS is five times lower than the maximum, it may be harder to develop a design that gives relatively good efficiency at both the average and maximum feed conditions.

9.4.2 Recommended Treatment

Based on the water quality evaluation results, RO treatment is recommended for the Chickahominy River. The proposed treatment schematic is shown on Figures 9-2 and 9-3. The capacity and treatment process requirements for the Chickahominy River are similar to the capacity and treatment process discussed in Section 8.4.2 for the James River. The footprint of an 8-mgd treatment facility is estimated to require approximately 7 acres.

Although the treatment processes for the James and Chickahominy rivers are similar, the Chickahominy River has a lower feed TDS which reduces the feed pressure requirements. A membrane feed pressure of 440 psi is proposed for the Chickahominy River with a maximum feed TDS of 8,800 mg/L in comparison to a membrane feed pressure of 639 psi for the James River with a maximum feed TDS of 12,500 mg/L.

The RO system design concept for the Chickahominy River is based on a typical brackish surface water flux rate of 12 gfd with 40 vessels in the first stage and 20 vessels in the second stage, similar to the James River concept. With the maximum feed TDS in the range of 8,800 mg/L, a high rejection CPA5-LD brackish RO membrane can be used in the first stage with ultra-low pressure SWC6 SWRO membranes used in the second stage. This membrane configuration was selected to achieve JCSA's finished water TDS goal of <350 mg/l.[5] The use of brackish water membrane elements in the first stage tends to reduce the operating pressure compared to the use of all SWRO membrane elements for the James River concept. The lower operating pressure indicates that the Chickahominy power consumption and operating cost should be lower than the James River case.

An interstage turbocharger energy recovery system is included in this design concept similar to the York and James River concepts. An RO system recovery of 75 percent was used for this site, although if more information on the scaling potential at this site was available, it might be possible to increase the system recovery to 80 percent.

[5] Movahed, Ben, "Five Forks RO plant in Virginia after 1 year of successful operation" American Membrane Technology Association. 2006. New Facilities Solutions. Table 1. Page 5. (http://www.amtaorg.com/wp-content/uploads/AMTA_Summer06.pdf (Last accessed February 12, 2015)

9.5 Physical Infrastructure Impacts

Based on the location of the Chickahominy River RO treatment facility on the James City County River Front Park property, approximately 26,000 feet of 36-inch diameter main will be required from an 8-or 12-mgd water treatment facility to the existing 16-inch diameter main on John Tyler Highway (Route 5). Additional infrastructure improvements may also be required within the existing system to transmit the flow to the demand centroid. It is recommended that JCSA conduct simulations on their hydraulic water model to define the infrastructure needs for the Chickahominy River RO plant to be hydraulically effective for their system.

9.6 Financial Impacts

Planning-level cost estimates for the Chickahominy River water treatment facility are presented in Table 9-3. The planning-level cost estimates assume that the water treatment facility will be located on the James City County Chickahominy River Front Park property and do not include infrastructure improvements necessary to distribute the flow in the system.

Planning-level O&M costs are presented in Table 9-4. The O&M costs were developed in a similar manner as the O&M costs for the York River as discussed in Section 7.6.

9.7 Potential Environmental Concerns

Implementation of the Chickahominy River water supply option may cause the following potential environmental concerns:

- Impact to the following ecological communities as identified in the Virginia Department of Conservation and Recreation, Natural Heritage Inventory and defined as "habitat of rare, threatened, or endangered plant and animal species, rate or state significant natural communities or geologic sites, and similar features of scientific interest"[6]:
  - Fluvial Terrace Woodlands
  - Coastal Plain/Piedmont Swamp Forests
  - Tidal Bald Cypress Forests and Woodlands
  - Tidal Freshwater and Oligohaline Aquatic Beds
- Impact to the 30-mile segment from Providence Forge to the James River classified in the National Park Service, National Rivers Inventory as having Outstanding Remarkable Value designations of Botanic ("An extensive, well developed cypress-gum swamp forest and bottomland hardwood forest which includes three rare, endemic and possibly endangered species of plants." and Geologic ("Extreme topographic diversity including cliffs up to 100 feet high at Fish Hole Landing.").[7]
- Impact to Riverine wetland areas[8]

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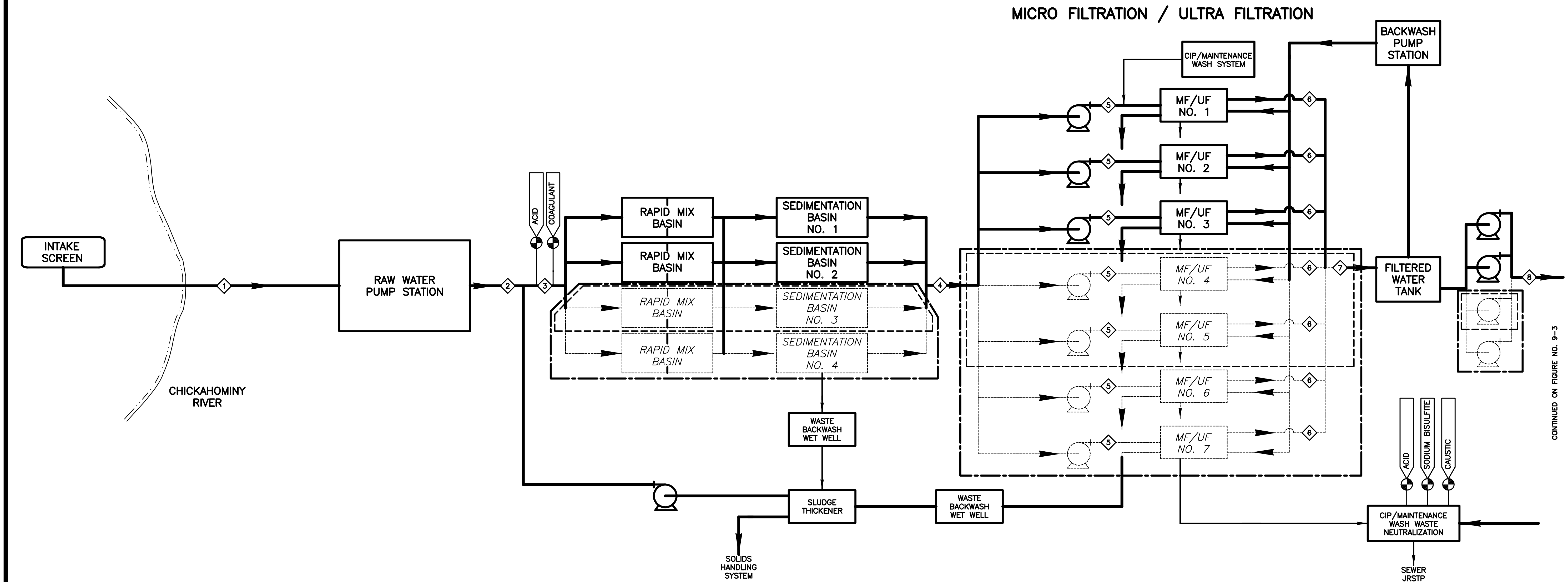
[6] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Page 3-13.

[7] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Table 3-9.

[8] Hampton Roads Planning District Commission. 2011. *Hampton Roads Regional Water Supply Plan.* Table 3-12.



PROCESS DATA

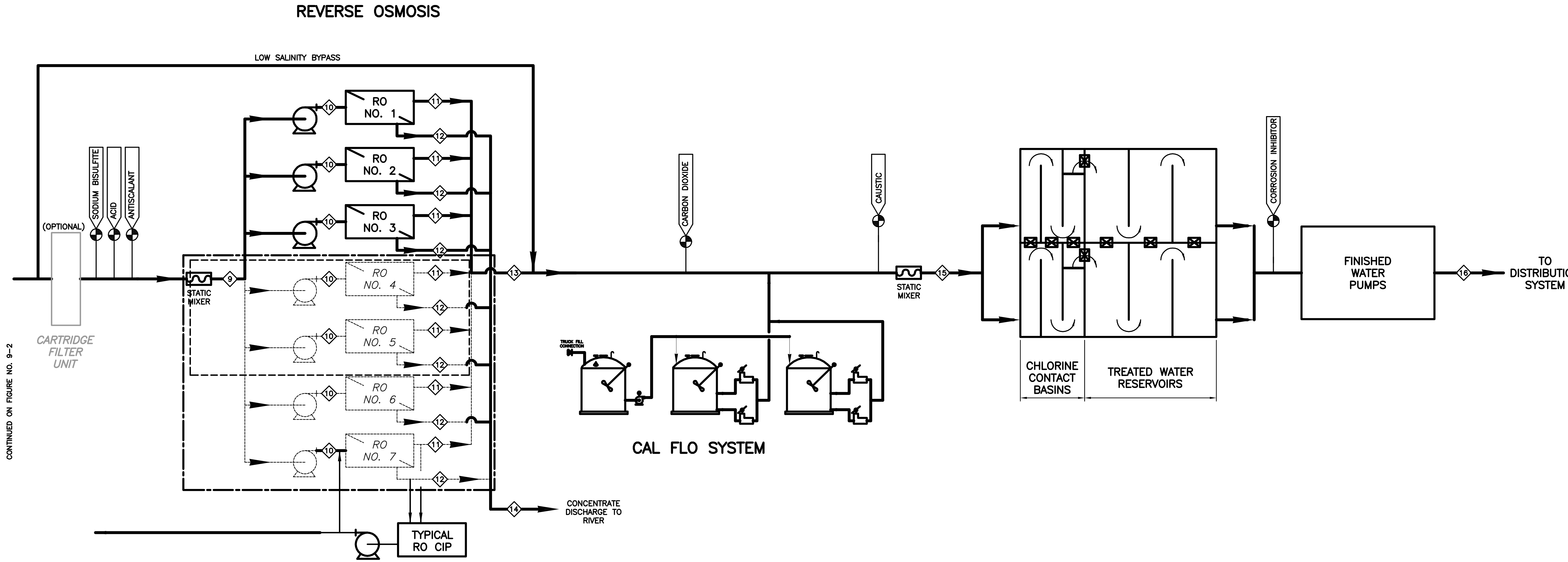
	1	2	3	4	5	6	7	8
FLOWS:								
Phase 1 MGD	5.72	5.72	5.72	5.61	2.81	2.67	5.33	5.33
Build-out MGD	17.17	17.17	17.17	16.84	2.81	2.67	16.0	16.0
CONSTITUENTS:								
TDS, Avg. mg/L	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
TDS, Max. mg/L	8,800	8,800	8,800	8,800	8,800	8,800	8,800	8,800
TSS, Avg. mg/L	58	58	58	12	12	0.5	0.5	0.5
TSS, Max. mg/L								
PRESSURES:								
Avg. psi	atm	45	atm	atm	15	4	4	45
Max. psi	atm	45	atm	atm	35	4	4	45

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
12 - STREAM NUMBER

LEGEND:
- - - - 8 MGD
—-—- 12 MGD

CDM Smith

Figure No. 9-2
James City Service Authority
Chickahominy River Process Flow Diagram I - Clarification and MF/UF



CONTINUED ON FIGURE NO. 9-2

PROCESS DATA

	9	10	11	12	13	14	15	16
FLOWS:								
Phase 1 MGD	5.34	2.67	2.0	0.67	4.0	1.34	4.0	4.0
Build-out MGD	16	2.67	2.0	0.67	12.0	4.0	12.0	12.0
CONSTITUENTS:								
TDS, Avg. mg/L	1,700	1,700	20	6,740	100	6,740	<100	<100
TDS, Max. mg/L	8,800	8,800	228	34,930	228	34,930	<300	<300
TSS, Avg. mg/L								
TSS, Max. mg/L	0.5	0.5	-	3	-	3	-	-
PRESSURES:								
Avg. psi	30	197	10	249	15	10	8	50
Max. psi	30	440	10	653	15	10	8	50

Column Numbers = Stream ID Numbers
(*) - Denotes Intermittent Flow on a Daily Basis
1 AT MAX TDS MIN TEMP
2 AT MAX TDS MAX TEMP
12 - STREAM NUMBER

LEGEND:
- - - - 8 MGD
—·—·— 12 MGD

CDM Smith

Figure No. 9-3
James City Service Authority
Chickahominy River Process Flow Diagram II - Desal & Post-Treatment

Table 9-2 Planning-Level Cost Estimate for Chickahominy River WTF (dollars)

Description	4-mgd Capacity		8-mgd Capacity		12-mgd Capacity	
Intake Facilities						
Intake	13,450,000		13,450,000		13,450,000	
Intake Pump Station	2,000,000		3,000,000		3,900,000	
Raw Water Pipeline	2,440,000		2,440,000		2,440,000	
Instrumentation – Intake Pump Station	570,000		860,000		1,100,000	
Electrical – Intake Pump Station	400,000		610,000		780,000	
Subtotal for Prime Contractor		18,860,000		20,360,000		21,670,000
Construction Contingency		4,720,000		5,090,000		5,420,000
Intake Facilities		23,580,000		25,450,000		27,090,000
Water Treatment Plant						
Yard Piping	1,850,000		2,070,000		2,300,000	
Site	4,460,000		5,310,000		6,160,000	
Pretreatment Basins	2,380,000		3,570,000		4,760,000	
Chemical Systems	3,480,000		4,050,000		4,620,000	
Administration Building	3,060,000		3,060,000		3,060,000	
Process Building	14,880,000		23,510,000		32,140,000	
CCT/Finished Water Storage	1,270,000		1,270,000		1,270,000	
Finished Water Pump Station	2,230,000		3,310,000		4,010,000	
Sludge Processing	950,000		1,420,000		1,890,000	
Instrumentation – WTP	1,280,000		1,420,000		1,570,000	
Electrical – WTP	4,300,000		4,830,000		5,370,000	
Concentrate Discharge Main	1,000,000		1,000,000		1,000,000	
Subtotal for Prime Contractor		41,140,000		54,820,000		68,150,000
Construction Contingency		10,290,000		13,710,000		17,040,000
Water Treatment Plant		51,430,000		68,530,000		85,190,000
Transmission Main						
Approximately 26,000 feet of 36-inch diameter main	13,000,000		13,000,000		13,000,000	
Subtotal for Prime Contractor		13,000,000		13,000,000		13,000,000
Construction Contingency		3,250,000		3,250,000		3,250,000
Transmission Main		16,250,000		16,250,000		16,250,000
Total Construction Cost in 2015 dollars	**91,260,000**		**110,230,000**		**128,530,000**	
Engineering, Legal, and Financial Fees	13,690,000		16,530,000		19,280,000	
Pilot Testing	500,000		500,000		500,000	
Permitting	500,000		500,000		500,000	
Total Project Costs in 2015 dollars	**$105,950,000**		**$127,760,000**		**$148,810,000**	
Total Project Costs in 2015 dollars per million gallons treated	**$26,487,500**		**$15,970,000**		**$12,400,800**	

Notes:

1. All costs expressed in 2015 dollars.
2. Existing distribution system should be evaluated to determine if the flow will require additional infrastructure improvements.

Table 9-3 Planning-Level O&M Cost Estimate for 8-mgd Chickahominy River WTF

Description	Annual O&M Cost $
Chemical Usage	1,250,000
Energy Consumption	1,270,000
Sludge Disposal	210,000
Labor	640,000
Equipment Maintenance/Repairs, annualized	1,290,000
Subtotal	4,660,000
Contingency	470,000
Total O&M Cost	5,130,000
	$ 1.76/1000 gal

Note: All costs expressed in 2015 dollars.

The potential impact of the following environmental factors may also be of concern to the public:

- Potential presence of kepone, a pesticide that was discharged upstream in the 1970s and trapped in the bottom sediments of the James River, that may be at the confluence of the Chickahominy River due to tidal influence
- Potential spill upstream in the vicinity from an automotive bridge crossing and Colonial Petroleum pipeline crossing
- Boat traffic

These potential environmental concerns may impact the ability to obtain permits and approval requirements that are identified in Section 11.

Section 10

Groundwater Sources

10.1 Aquifer Description

James City County is underlain by a seaward-thickening wedge of unconsolidated to partially consolidated layers of sediment deposits with bedrock lying more than 1,200 feet below sea level. As described in Section 3, JCSA currently withdraws water from the aquifers identified as the Lower Potomac, Middle Potomac, Upper Potomac, and Chickahominy Piney Point. Recent interpretations suggest that the Upper, Middle, and Lower Potomac may function as a single aquifer within portions of the EVGMA; however, JCSA has not seen written confirmation that the single aquifer interpretation applies to their location.

The Chesapeake Bay impact crater is located east of James City County. Figure 10-1 presents a generalized hydrogeologic section through the Virginia Coastal Plain. Chloride and total dissolved solids concentrations generally increase with increasing depth and from west to east.

The aquifers underlying James City County are not uniform but consist of alternating layers of sand, silt, clayey sand, and clay. Wells constructed in these aquifers are generally screened in the sand layers to take advantage of the higher productivity. Depending on the specific aquifer and location, these sand units are not laterally continuous or of uniform thickness. This may result in changes in aquifer productivity and water quality over short distances.

10.2 Available Groundwater Supply Resources

As is the experience in existing JCSA wells, individual wells screened in the Potomac and Piney Point aquifers can be quite productive and represent a viable water supply source. Water quality considerations require membrane treatment and or blending of waters to provide an acceptable water supply. However, published data and studies indicate that current and planned future groundwater withdrawal rates may be exceeding the rates of freshwater recharge in the regional aquifer system and raising concerns with declining water levels, increasing chloride concentrations, and land subsidence. Specifically of concern is that the regionally declining water levels will cause the violation of the 80- percent drawdown criteria.

As discussed in Section 2, DEQ and other agencies are developing and implementing strategies to better manage the groundwater resource. As presented in a recent article in the Hampton Roads Planning District Commission Water Resources News (October 21, 2014), DEQ has proposed decreasing permitted groundwater withdrawal rates for 14 of the largest permitted groundwater users in the EVGMA. Four users, including JCSA, have the proposed target less than their current use. Hence, based on DEQ's withdrawal reduction strategy, the expansion of JCSA groundwater withdrawals is not a viable option at this time.

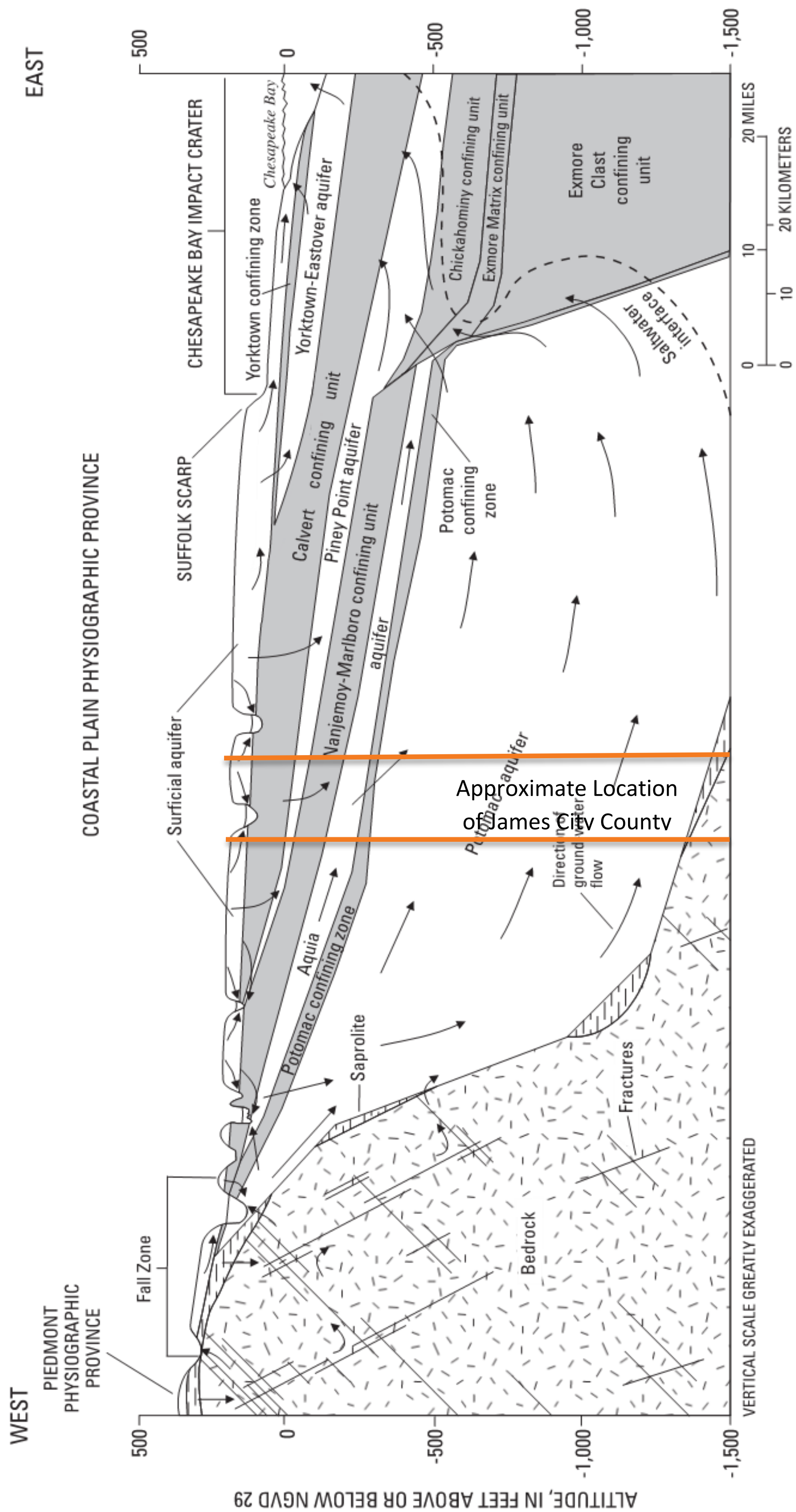


Figure 10-1
Generalized Hydrogeologic Section in the Virginia Coastal Plain (McFarland and Bruce, 2006)

10.3 Riverbank Filtration

Riverbank filtration is a method of withdrawing water from a surface water source by first passing the water through the natural river sediments. This is typically accomplished by constructing shallow wells near the river. Where conditions are appropriate, this sometimes consists of a larger diameter vertical well or shaft with horizontal wells extending radially outward to collect the water. Historically, riverbank filtration systems have been constructed in unconsolidated sand and gravel alluvial deposits near the river bank. Pumping water from the wells produces a gradient that causes river water to move through the sediment towards the well. The filtration of the water through the sediment deposits effectively removes pathogens, reduces organic matter (as measured by soluble organic carbon (SOC)), and removes suspended solids thereby reducing the need and cost of treatment. This also produces a more constant water quality that would improve the treatment process and provide a consistent high quality treated water supply. A further benefit is that it eliminates a direct withdrawal from the river that would have other concerns such as impacting small fish and other aquatic organisms in the water. A direct withdrawal would have to have fine screens and sufficient surface area to reduce the impact on aquatic organisms.

James and York rivers in the areas of interest are brackish with total dissolved solids concentrations varying seasonally. Water withdrawn through the use of riverbank filtration would still require treatment through membranes or other technology to reduce sodium, chloride, and other dissolved solids concentrations to acceptable levels. Riverbank filtration would eliminate the need for sedimentation to address suspended solids and reduce concentrations of bacteria and other organisms that affect the treatment process. Fine screens and filters would be required to prevent membrane clogging by fine particulates in the water withdrawn from the wells. Riverbank filtration would dampen the fluctuations in suspended solids and dissolved solids water quality associated with a direct river withdrawal.

The James River, York River, and downstream tidal portions of the Chickahominy River in the areas of interest near James City County are flooded river valleys. Ancient rivers cut through the deposits when ocean water levels were lower than today and are now tidal estuaries. As such, the riverbanks consist of the unconsolidated and semi-consolidated sediments that comprise the surficial aquifer system. This typically consists of nearly horizontal layers of sand, silty sand, and clay. The layers typically are not horizontally continuous. The local soils are therefore not typical for locations where riverbank filtration is used and extensive testing and piloting would be required to determine if this option is feasible and to provide data that will determine the number of wells required and the optimum well field configuration.

Conceptually, a riverbank withdrawal system for the Chickahominy, York or James River would include multiple shallow wells near the riverbank. The wells could be drilled at an angle to follow the riverbank slope and maintain a constant distance between the well and the river. Depending on the strata found, the wells would be screened to take advantage of the more permeable layers. Exploratory wells would be needed to determine the strata at the specific site of interest. Chesapeake Bay Preservation Area requirements would likely require that the wells be constructed at least 100 feet from the shore. To ensure that much of the water is obtained through induced flow from the river source, the wells should be as close to the river as feasible. A conceptual plan and profile for riverbank filtration along the James, Chickahominy, or York River is shown on Figure 10-2.

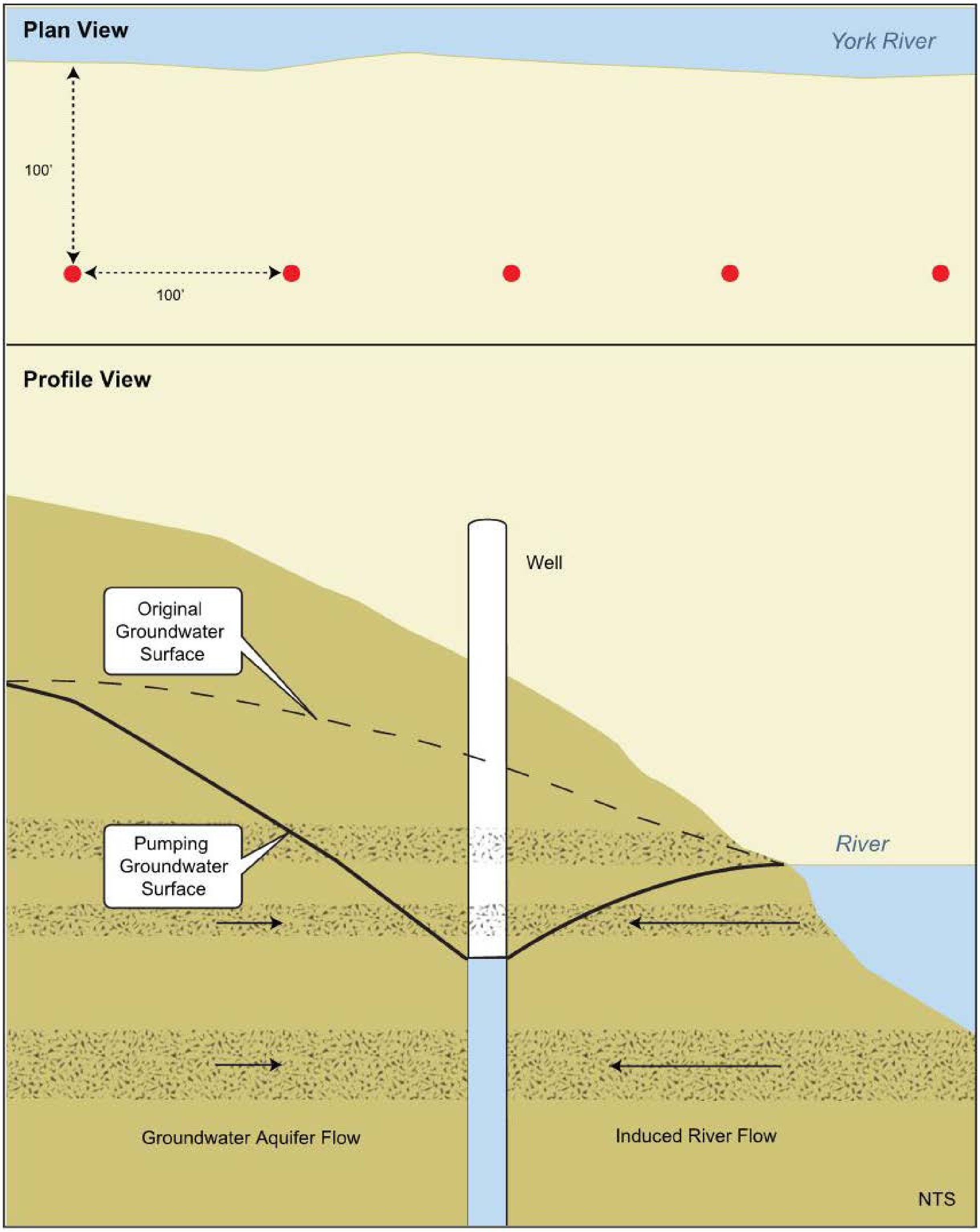


Figure 10-2
Chickahominy, James, and York River
Riverbank Filtration Conceptual Plan and Profile

As an initial conceptual requirement it is assumed that each shallow well could reliably produce 0.12 mgd. A 1-mgd water supply, including 80 percent reject from the RO membranes, would require approximately 10 wells. To avoid inter-well interference, a well-to-well spacing of 100 feet is assumed. This would require a linear well field about 1,000 feet long. Other well field configurations could be considered.

The regulatory requirements of riverbank filtration withdrawal are uncertain. The riverbank withdrawal wells would be constructed in the same stratum that comprises the surficial water system and would likely be regulated by DEQ under the EVGMA. The water withdrawn from the wells would include both river water induced to flow to the well and groundwater. The amount of groundwater withdrawn and impact on the aquifer depends on the local stratigraphy and natural groundwater flow gradients. The naturally occurring groundwater flow direction would be towards the river with the groundwater levels being higher than the river levels. If there were a nearby significant existing groundwater withdrawal, the natural gradient could be away from the river into the aquifer. It would likely not be possible to design and construct a riverbank withdrawal that would not affect the localized groundwater aquifer. DEQ may also raise concerns regarding the riverbank filtration system inducing saltwater intrusion into the local aquifer system.

VDH indicated that the Virginia Water Authority operates a membrane filtration plant with a riverbank filtration source.[1] The infiltration gallery is along the New River in Grayson County which is a freshwater flowing river outside the EVGMA in contrast to the James River which is a brackish tidal river. The New River riverbank infiltration gallery has a design capacity of 1.0 mgd.[2]

10.4 Expansion of the FFWTF from 5 to 6 mgd

For this study, a 20-percent expansion of the FFWTF from 5.0 to 6.0 mgd was considered using riverbank filtration for the James River. It is assumed that the wells would be constructed on the County-owned parcel along the James River, west of the FFWTF concentrate discharge main. As discussed above, it is assumed that a 1-mgd supply, including 80 percent reject from the RO membranes, would require approximately 10 wells, spaced at least 100 feet apart. It is assumed that additional skids and other modifications may be necessary to expand this facility and can be located within the existing structures.

10.5 Physical Infrastructure Impacts

Additional infrastructure improvements may be required within the existing water system to transmit additional flow from the FFWTF to the demand centroid. It is recommended that JCSA conduct simulations on their hydraulic water model to define the infrastructure needs for the FFWTF expansion.

10.6 Financial Impacts

Planning-level cost estimates for the FFWTF 1-mgd expansion are presented in Table 10-1. The planning-level cost estimates do not include costs for infrastructure improvements that may be necessary to distribute the flow in the system.

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[1] Ray Whitner, VDH Office of Drinking Water-Abingdon Field Office (personal communication, November 24, 2014).

[2] VDH Engineering Description Sheet, Virginia Water Authority, Permit No. 1077825, Effective July 1, 2013.

Table 10-1 FFWTF 1-mgd Expansion Planning-Level Cost Estimates

Description		Planning-Level Cost Estimate ($)
Riverbank filtration wells	1,300,000	
1-mgd plant expansion	10,000,000	
Subtotal for Prime Contractor		11,300,000
Construction Contingency		2,830,000
Total Construction Cost		14,130,000
Engineering, Legal, and Financial Contingencies		3,530,000
Total Project Costs in 2015 Dollars		**17,660,000**

Note: Assumes 10 wells installed on County-owned property adjacent to concentrate discharge and that capacity of existing concentrate discharge main is adequate.

Annual O&M costs were also developed for the plant expansion. The O&M cost is presented in Table 10-2 and includes costs associated with chemical usage, energy consumption, and labor costs. The O&M costs were based on unit costs provided by JCSA for chemical purchase, power, and staffing. Under JCSA's budgeting program, membrane replacement and equipment maintenance/repairs for the FFWTF are funded separately from the annual O&M cost and are therefore not included in Table 10-2. The estimated O&M cost for the 5-mgd FFWTF is $0.62/1,000 gallons. The O&M cost is estimated to increase to $0.72/1,000 gallons with the 1-mgd plant expansion; the cost increase includes additional staffing requirements to man the facility 24 hours per day as required for the plant capacity.

Table 10-2 Planning-Level Cost Estimate for FFWTF 1-mgd Expansion

Description	Annual O&M Cost $
Chemical Usage	170,000
Energy Consumption	640,000
Labor	610,000
HRSD Fee	5,000
Landscaping and Mowing	5,000
Subtotal	1,430,000
Contingency	140,000
Total O&M Cost	1,570,000
	$0.72/1,000 Gal

*All Costs expressed in 2015 dollars.

10.7 Potential Environmental Concern

The impact of the riverbank filtration wells on the aquifer is a potential environmental concern to DEQ. Although the primary water source is surface water from the James River, it is uncertain how DEQ will relate the riverbank filtration to the groundwater withdrawal permit. As previously discussed, the water withdrawn from the wells would include both river water induced to flow to the well and groundwater, with the amount of groundwater withdrawn and impact on the aquifer dependent on the local stratigraphy and natural groundwater flow gradients.

The impact of the potential presence of kepone that was discharged upstream into the James River in the 1970s and trapped in the bottom sediments of the river is of potential environmental concern for riverbank filtration on the James River as well as its confluence with the Chickahominy River. It is uncertain if the riverbank filtration withdrawal will disturb the sediments. Further investigation with water sampling from test wells is necessary to determine the potential impact. Prior to sampling, a Health and Safety Plan would need to be developed. EPA Method 8270 will allow for analysis of this compound. The quantity of water that would need to be pumped for the riverbank filtration testing program will have to be established. Disposal methods for the pump test water would have to be identified as part of the riverbank filtration testing program in case kepone is detected in the water sample. The water will have to be containerized pending analytical results.

Section 11

Permit and Approval Requirements

The implementation of a new and/or expanded water supply and treatment facility will require permits and approval from various regulatory agencies. A discussion of the permit and approval requirements for the surface water and groundwater supply and treatment alternatives follows.

11.1 Surface Water Supply

To implement a new surface water supply and treatment facility, permits and review approvals will be needed from the following regulatory agencies:

- Federal
  - United States Army Corps of Engineers
  - United States Environmental Protection Agency
  - National Park Service
- State
  - Virginia Department of Environmental Quality
  - Virginia Department of Conservation and Recreation
  - Virginia Department of Game and Inland Fisheries
  - Virginia Marine Resources Commission
  - Virginia Department of Health
  - Virginia Department of Transportation
- Local
  - James City County Planning Division
  - James City County Division of Engineering and Resource
  - James City County Building Safety and Permits Division

A discussion of each regulatory agency's involvement in the permit and review approval process follows.

11.1.1 Federal

11.1.1.1 U.S. Army Corps of Engineers (USACE)

The USACE is responsible for administrating the requirements of Section 10 of the Rivers and Harbors Act (Section 10) and Section 404 of the Clean Water Act (Section 404). Section 10 of the Rivers and Harbors Act regulates activity within navigable waters of the United States. Activities regulated by Section 10 include any action that would affect the course, location, condition, or capacity of navigable waters including construction, excavation, and deposition of materials. Section 404 governs the discharge of dredged or fill material into waters of the United States. USACE jointly administers

Section 404 authority with EPA. Construction of the intake and disposal of the concentrate in the York, James, or Chickahominy rivers, as well as any construction impact to wetlands, will require a USACE permit. For the Chickahominy River, potential impact to Riverine wetlands will be of concern.

11.1.1.2 U.S. Environmental Protection Agency (EPA)

While the permit decisions and jurisdictional determinations for Section 404 are made by USACE, EPA is responsible for the overall implementation of the Clean Water Act. EPA involvement is limited mostly to providing review and comment; however, EPA has the authority to prohibit or restrict the use of any defined area as a disposal site or reject USACE permit decisions. In Virginia, the National Pollutant Discharge Elimination System (NPDES) permit program authorized by the Clean Water Act is regulated by DEQ under the VPDES program. EPA also has oversight responsibilities over state and local permitting authorities, such as DEQ, in the issuance of operating permits for air pollution sources under Title V of the Clean Air Act.

11.1.1.3 National Park Service

The National Park Service maintains the Nationwide River Inventory which is a "register of river segments that potentially qualify as national wild, scenic or recreational river areas".[1] To be registered, the river must be free-flowing and have an Outstanding Remarkable Value (ORV) designation. The National Park Service will be concerned about the potential impact of the water supply alternatives to the following National River Inventory segments:

- Chickahominy River - 30-mile segment from Providence Forge to the James River classified as having botanic and geologic significance
- James River - 62-mile stretch from Hopewell to Mogarts Beach designated as having a historic significance. Four National Historic Register Sites and one National Historic Park are also located adjacent to the corridor.[2]
- York River – 12-mile section from Almondsville to Plum Point designated as having hydrologic significance

11.1.2 State

11.1.2.1 Virginia Department of Environmental Quality (DEQ)

Protection and improvement of the environment in Virginia is DEQ's primary mission. To achieve this mission, DEQ implements laws and regulations governing air quality, water quality, water supply, and waste management. As a result of their broad mission, DEQ administers numerous permitting programs.

Surface water withdrawal projects are regulated by the Virginia Water Protection (VWP) Permit Program which is administered by the DEQ Office of Wetlands and Stream Protection and the DEQ Office of Water Supply.[3] The VWP Permit is issued through the Joint Permit Application (JPA) process, which allows for concurrent review by the USACE, the Virginia Marine Resources Commission, DEQ, and local wetlands boards. The JPA may also be sent to other agencies for comment.

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[1] Hampton Roads Planning District Commission. 2011. Hampton Roads Regional Water Supply Plan. Page 3-17.

[2] Hampton Roads Planning District Commission. 2011. Hampton Roads Regional Water Supply Plan. Table 3-9.

[3] http://www.deq.virginia.gov/Programs/Water/WetlandsStreams/SurfaceWaterWithdrawalsImpoundments.aspx (Last accessed November 6, 2014)

In accordance with 9VAC25-210-75, JCSA can request DEQ to form a preapplication review panel to assist in the early identification of issues related to the protection of beneficial instream and offstream uses of the river. DEQ would notify the Virginia Marine Resources Commission, the Virginia Institute of Marine Science, the Virginia Department of Game and Inland Fisheries, the Virginia Department of Conservation and Recreation, the Virginia Department of Health, USACE, the U.S. Fish and Wildlife Service, EPA, and any other appropriate local, state, and federal agencies of the preapplication review panel request. The agencies would provide information and guidance on the potential natural resource impacts and regulatory implications of the project and provide comments within 60 days of the initial meeting of the preapplication panel.

The concentrate discharge from the RO treatment facility will require a VPDES permit which is issued by DEQ. Potential impacts to the receiving stream will need to be addressed to obtain a VPDES permit.

11.1.2.2 Virginia Department of Conservation and Recreation (DCR)

DCR protects Virginia's natural and cultural treasures through the management of erosion, sediment runoff, and stormwater resulting from land disturbing activities, which is documented in the Virginia Stormwater Management Program. DCR maintains a natural heritage inventory which documents the location and ecological status of habitat of rare, threatened, or endangered plant and animal species, significant natural communities or geologic sites and administers the Virginia Scenic Rivers program. Potential DCR concerns for the surface water supply alternatives are summarized in Table 11-1.

Table 11-1 Potential DCR Concerns on JCSA Surface Water Supply Alternatives

Surface Water Supply	Potential DCR Concern
Chickahominy River	Impact to following ecological communities identified in Natural Heritage Inventory • Fluvial Terrace Woodlands • Coastal Plain/Piedmont Swamp Forests • Tidal Bald Cypress Forests and Woodlands • Tidal Freshwater and Oligohaline Aquatic Beds
James River	Impact to tidal bald cypress forests and woodlands along the James River near Swanns Point, Surry County, as identified in the DCR Natural Heritage Inventory
	Impact to the 25-mile segment of James River from 1.2 miles east of Trees Point to Lawnes Creek designated as a Scenic River by DCR

11.1.2.3 Virginia Department of Game and Inland Fisheries (VDGIF)

VDGIF is tasked with protecting threatened and endangered wildlife. If threatened or endangered species are encountered during the construction of the water intake and/or treatment facility, a permit to collect and relocate the species may be required.

11.1.2.4 Virginia Marine Resources Commission (VMRC)

VMRC permits most activities over, under, or on state-owned submerged lands. The Habitat Management Division Permit will be required for the intake.

VMRC will be concerned about the potential impact of the York River surface water supply alternative to the York River shellfish management area defined by VMRC between Gloucester Point and Clay Bank Wharf.

11.1.2.5 Virginia Department of Health (VDH)

VDH Office of Drinking Water advocates for safe drinking water on behalf of the public through water quality monitoring, use of engineering judgment, technical assistance, and regulatory enforcement. The intake and treatment facility design must be submitted to VDH for approval. VDH is responsible for issuing JCSA's Waterworks Operation Permit which indicates the approved capacity of the system. JCSA would need to apply for an amendment to the Waterworks Operation Permit to include the new water supply and treatment facility.

In 1997, VDH had strong opposition to the use of the James River below Hopewell as a public water supply source. The presence of kepone trapped in the bottom sediment of the James River was identified as a potential concern. It is uncertain if VDH will continue to have the same opposition today for the development of the James River as a water supply source. The impact of VPDES permitted discharges in the vicinity of a proposed James River intake, boat traffic, and potential spills upstream from major highway/railway crossings may also be of concern to VDH.

Similarly, the impact of potential spills from an automotive bridge crossing and Colonial Petroleum pipe line crossing on the Chickahominy River intake may be of concern to VDH for the development of the Chickahominy River as a water supply source. It is uncertain if the presence of kepone will also be of concern in the tidal section of the Chickahominy River.

11.1.2.6 Virginia Department of Transportation (VDOT)

All activities that affect state highways or rights-of-way must be reviewed by VDOT and receive a Land Use Permit. Activities for this project that will need review include the construction and permanent access roads and utility crossings.

11.1.3 Local

11.1.3.1 James City County Planning Division

The site plan for the water treatment facility must be submitted to the James City County Planning Division for review and approval. The site plan is reviewed by the Development Review Committee. A building permit will not be issued until the site plan has been approved.

The construction and operation of the water treatment facility will require a Special Use Permit which is processed and reviewed by the Planning Division. The Special Use Permit authorizes a use in a specific zoning district that will comply with all the conditions and standards for the location or operation of the use as specified in the zoning ordinance and authorized by the Board of Supervisors. The impact of the use on neighboring property and surrounding areas as well as compatibility with the James City County Comprehensive Plan is taken into consideration.

A Special Use Permit will be more difficult to obtain for the James River surface water treatment facility than the Chickahominy and York River water treatment facilities since most areas in the vicinity of the James River are already developed and/or protected from development.

11.1.3.2 James City County Division of Engineering and Resource Protection

The James City County Division of Engineering and Resource Protection is responsible for reviewing stormwater management plans to ensure compliance with the Virginia Stormwater Management Program (VSMP). The County reviews and approves Stormwater Pollution Prevention Plans, which include sedimentation and erosion control plans and stormwater management plans. The County is responsible for issuing a consolidated erosion and sediment control (land disturbing) and stormwater management (stormwater construction) permit and obtaining evidence of VPDES/VSMP permit coverage prior to approval to begin land disturbance activities.[4]

11.1.3.3 James City County Building Safety and Permits Division

The James City County Building Safety and Permits Division is responsible for ensuring that public/private structures and facilities constructed in the County do not harm the public's safety and welfare as well as enforcing zoning ordinances. To achieve this goal, the Safety and Permits Division reviews design and construction plans, oversees construction permitting, and issues final approval for occupancy of the project. The water supply and treatment facility will require building, mechanical, plumbing, electrical, and occupancy permits.

11.2 Groundwater

An expansion of the FFWTF will require permit and review approvals from similar agencies as the surface water supply option. A discussion of the involvement of each agency follows.

11.2.1 Federal

USACE and EPA involvement focuses on permits required if the construction of the pipeline from riverbank filtration wells to the FFWTF impacts any wetland area.

11.2.2 State

DEQ is responsible for reviewing modifications to the Groundwater Withdrawal Permit, VPDES permit for the brine concentrate discharge, and air quality, water quality, and waste management permits. Since the riverbank filtration wells would be constructed in the same stratum that comprises the surficial aquifer, it will likely be regulated by DEQ under the EVGMA; it is uncertain how DEQ will relate the riverbank filtration wells to the groundwater withdrawal permit. For an expansion of the FFWTF, a modification to the VPDES permit for the concentrate discharge is required.

VDH is responsible for approving the design for the plant expansion and providing a permit to construct the facility. JSCA will also need to request an amendment to the Waterworks Operation Permit for the expanded facility and new RO facility.

11.2.3 Local

Local permit requirements are similar to those discussed in Section 11.1.3 for new construction.

11.3 Summary

A summary of the permit and approval requirements for the surface water and groundwater supply and treatment alternatives is presented in Table 11-2. The summary includes a rating for the degree of difficulty in obtaining the permits and approvals with "1" as the easiest and "5" as most difficult. Of the surface water supply options, permit and approval of the James River as a water supply source presents the most challenges due to potential environmental impacts and impacts of existing conditions and permitted discharges on raw water quality. The permitting and approval of the 1-mgd expansion of the FFWTF is highly dependent on how DEQ will relate the riverbank filtration wells to the Groundwater Withdrawal Permit; the alternative will not be viable if DEQ determines that the riverbank filtration flow impacts JCSA's permitted groundwater withdrawal.

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[4] http://www.jamescitycountyva.gov/pdf/resourceprotection/Forms-all/VSMPgeneral.pdf (Last accessed February 10, 2015)

Table 11-2 Permit and Approval Summary

			Applicability		Difficulty in Obtaining Permit (1 = Easy, 5 = Difficult)			
Permit	Responsible Agency	Description	New Surface Water Source	FFWTF Expansion	York River WTF	James River WTF	Chickahominy River WTF	FFWTF Expansion with Riverbank Filtration of James River
Dept. of the Army Permit (Section 404/Section 10 of Clean Water Act)	USACE	Required for construction in navigable waters or discharge of dredged or fill material into waters of the U.S., including wetlands	✓		4	5	5	
Virginia Water Protection Permit (VWP)	DEQ	Required for impacts to wetlands and/or waterways, water intakes, outfalls	✓		4	5	5	
Virginia Groundwater Withdrawal Permit	DEQ	Required for groundwater withdrawal >300,000 gpd		✓				5
VPDES Permit	DEQ	Required for brine concentrate discharge and if JCSA desires to have flexibility of disposal of process wastewater such as during start-up	✓	✓	3	3	3	3
VPDES/VSMP Permit for Construction	JCC DERP	Obtain evidence of general permit coverage	✓	✓	2	2	2	2
Stormwater Pollution Prevention Plan	JCC DERP	Required for discharge of stormwater from construction activities	✓	✓	2	2	2	2
Virginia Pollution Abatement Permit	DEQ	Required if JCSA land applies wastes						
VDOT Land Use Permit	VDOT	Required for facility entrance (temporary and permanent driveway) and construction of water mains in VDOT right-of-way	✓		2	2	2	
Site Plan Approval	JCC PD	Required prior to building permit approval	✓	✓	3	3	3	2
Special Use Permit	JCC PD	Required for construction and operation of water treatment facility	✓	✓	2	4	2	4
VDH Permit to Construct	VDH	Required before Notice to Proceed	✓	✓	3	3	3	3
Building, Mechanical, Plumbing, Electrical Permits	JCC BSPD	Required for construction approval	✓	✓	2	2	2	2
Waterworks Operation Permit	VDH	Required before plant goes on line	✓	✓	3	3	3	3
Emergency Generator General Permit	DEQ	Required for emissions from onsite generator	✓	✓	2	2	2	2
Fuel Tank Registration	DEQ	Required for fuel tanks	✓	✓	2	2	2	2
Spill Prevention Control and Countermeasure Plans (SPCC)	DEQ/EPA	Required for onsite chemicals and fuel storage	✓	✓	2	2	2	2
Electric – Request for Commercial Hookup	Electric Utility	Discuss during start of design	✓	✓	2	2	2	2
Occupancy Permit	JCC BSPD	Required for building occupancy	✓	✓	2	2	2	2

✓ = Required

Abbreviations:

USACE = U.S. Army Corps of Engineers
DEQ = Virginia Department of Environmental Quality
EPA = U.S. Environmental Protection Agency
JCC BSPD = James City County Building Safety and Permits Division
JCC DERP = James City County Division of Engineering & Resource Protection
JCC PD = James City County Planning Division
VDH = Virginia Department of Health
VDOT = Virginia Department of Transportation

Section 12

Evaluation Results of Potential Alternatives

A summary of the evaluation results of the following water supply alternatives is presented in Table 12-1:

- Newport News Waterworks
- York River
- James River
- Chickahominy River
- Expansion of existing FFTWF from 5 to 6 mgd with riverbank filtration of the James River

The general location of each alternative is shown on Figure 12-1. A discussion of the evaluation results follows.

12.1 Newport News Waterworks

With the existing DEQ Groundwater Withdrawal Permit and reliance solely on their groundwater supply, JCSA is projected to have a deficit of 0.3 mgd by 2030, increasing to 3.4 mgd by 2050 based on the projected maximum day demands. If DEQ reduces the permitted average annual withdrawal to 7.84 mgd, the projected deficit is 1.2 mgd by 2030, increasing to 4.3 mgd by 2050. If DEQ reduces the permitted annual average withdrawal to their proposed limit of 4.0 mgd, JCSA will have an immediate deficit of 2.0 mgd, increasing to 8.2 mgd by 2050.

JCSA entered into a PDA with Newport News in 2008 to purchase supplemental water through two payment installments. JCSA's first payment of 25 million dollars gives the Authority the right to purchase an average safe yield of 4 mgd during drought conditions; the actual cost of the payment was $51.5 million including debt service. If the second payment of 25 million dollars (in 2008 dollars subject to inflation i.e. approximately 34 million dollars in 2019 dollars) is not paid by June 30, 2019, JCSA's safe yield share will be limited to 2 mgd on an annual average; the second payment is estimated to cost JCSA $60 million to finance. With the existing DEQ Groundwater Withdrawal Permit and a supplemental annual average purchase of 2 mgd from Newport News, a deficit of 0.5 mgd is projected by 2050; a second payment to Newport News would delay the deficit beyond 2050. With a revised permitted average annual withdrawal of 7.84 mgd, the projected deficit is 1.5 mgd by 2050; a second payment to Newport News would delay the deficit beyond 2050.

In addition to the payment installments to Newport News, JCSA will need to implement infrastructure improvements, including disinfection compatibility improvements, in order for the Newport News water to be effective in meeting their water supply needs. The location of the two potential interconnections to the Newport News water system is shown on Figure 12-1.

If DEQ reduces the permitted annual average withdrawal to their proposed 4.0 mgd limit and JCSA purchases 2 mgd from Newport News, the projected deficit is 0.7 mgd by 2020, increasing to 5.3 mgd by 2050; if JCSA pays the second installment, the projected deficit is 0.9 mgd by 2040, increasing to 2.5 mgd by 2050. Hence, with a reduction in the DEQ permitted withdrawal to 4 mgd, the need to secure an additional water supply source is imminent for JCSA even with the Newport News water purchase.

JCSA will not be able to have a second water supply source online prior to the June 30, 2019 deadline for the second payment to Newport News due to the time required for permit approval, design, and construction of a new facility. With the existing permitted groundwater withdrawal, the cost to develop a long-term surface water supply source for JCSA should be compared to the cost of the second payment to Newport News to determine if the Newport News second payment is the most feasible option.

12.2 Surface Water Supply Sources

The York, James, and Chickahominy rivers are viable surface water supplies for JCSA. The York, James, and Chickahominy rivers all have brackish water with tidal influence and require RO treatment. Of the three surface water supplies, the Chickahominy River has the lowest estimated salinity and the York River, the highest.

The Chickahominy River and James River have more potential environmental concerns than the York River due to the presence of significant ecological communities, such as tidal bald cypress forests and woodlands. Potential impact to tidal fluvial terrace woodlands, coastal plain/piedmont swamp forests, and tidal freshwater and oligohaline aquatic beds, and riverine wetlands will also be of concern for the Chickahominy River. The James River segment considered for the raw water intake is designated as a Scenic River by DCR and as having historic significance by the National Rivers Inventory. The proposed Chickahominy River intake is located in a segment classified as having botanic and geologic outstanding remarkable values in the National Rivers Inventory.

The James River has more potential water quality impacts that may be of concern to the public than the York or Chickahominy River. There are six dischargers with VPDES permits in close proximity to the proposed raw water intake location. The potential presence of kepone trapped in the sediments that may be disturbed during construction is of concern; it is uncertain if kepone could be present in the tidal section of the Chickahominy River. With the York River alternative, discharges that are located approximately 10 miles upstream in West Point may be of concern. Potential spills from transportation vehicles on major highway crossings across the James River, a bridge crossing and petroleum pipe line crossing across the Chickahominy River, and boat traffic on both rivers are also of concern.

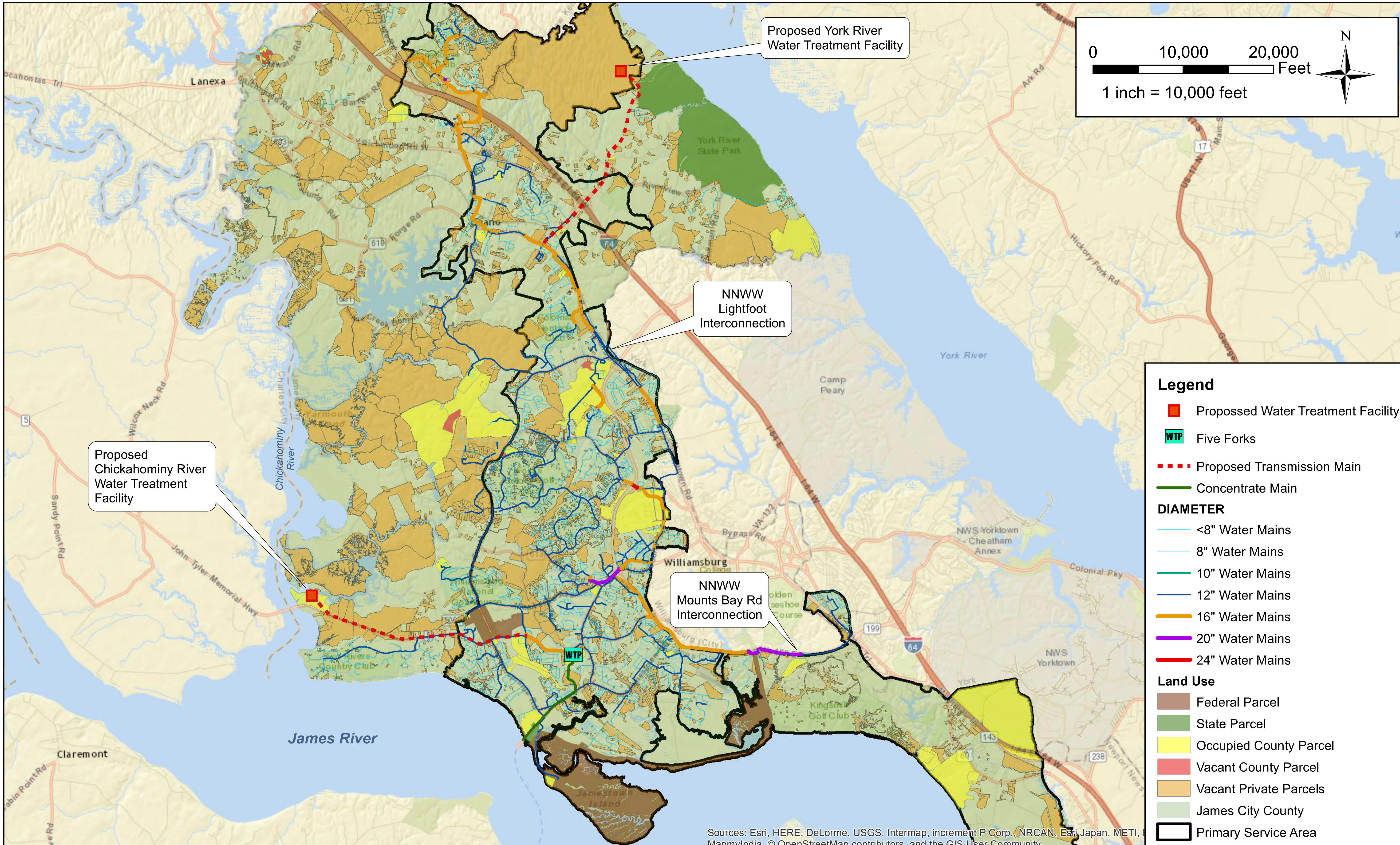
The James River and the York River have more flow than the Chickahominy River. The available flow in the Chickahominy River may also be limited during drought conditions based on the limits stipulated in the NNWW surface water supply agreement which restricts their flow during drought conditions; however, this limitation is on the fresh water side of the Chickahominy River and may not be applicable to the tidal section of the proposed intake.

Table 12- 1 Evaluation Results of Potential Water Supply Alternatives

	Newport News Water Works Purchase Agreement	York River	James River	Chickahominy River	Expansion of FFWTF
Description	Increase in purchase agreement from 2 mgd to 4 mgd	RO facility with intake close to Croaker Road	Intake located upstream of FFWTF concentrate discharge; site to be determined	RO facility located on County-owned Chickahominy River Front Park	Expansion of FFWTF from 5 to 6 mgd with 1 mgd obtained from riverbank filtration of James River
Planning-Level Capital Cost Estimate	MB = Mounts Bay Road Interconnection LT = Lightfoot Connection Scenario A: MB=2 mgd Infrastructure = $6M Scenario B: MB = 2mgd, LT = 2 mgd 2nd Payment w/debt service $60M Infrastructure Improvements 15M Disinfection Improvements 2M Total $77M Scenario C: LT = 4 mgd 2nd Payment w/debt service $60M Infrastructure Improvements 17M Disinfection Improvements 2M Total $79M	4-mgd Capacity / 8-mgd Capacity / 12-mgd Capacity Intake $ 20M / $ 22M / $ 23M WTF 45M / 60M / 76M Transmission 12M / 12M / 12M Contingencies 19M / 24M / 28M Engineering, Testing, Permitting, Land Acquisition 17M / 20M / 23M Total Project Cost $113M / $138M / $162M	4-mgd Capacity / 8-mgd Capacity / 12-mgd Capacity Intake[1] 19M / 20M / 22M WTF[2] 43M / 57M / 71M Transmission 5M / 5M / 5M Contingencies 17M / 21M / 24M Engineering, Testing, Permitting, Land Acquisition 16M / 19M / 22M Total Project Cost 99M / 122M / 144M Note: Refine cost for raw water transmission, concentrate discharge main, and finished water main after site is identified	4-mgd Capacity / 8-mgd Capacity / 12-mgd Capacity Intake $ 19M / $ 20M / $ 22M WTF 41M / 55M / 68M Transmission 13M / 13M / 13M Contingencies 18M / 22M / 26M Engineering, Testing, Permitting 15M / 18M / 20M Total Project Cost $106M / $128M / $149M	Riverbank Filtration Wells $ 1M 1-mgd plant expansion 10M Contingencies 3M Engineering, Testing, Permitting 4M Total Project Cost $18M
O&M Cost Estimate	Per NNWW PDA $1.22/1000 Gallons in 2014	$2.00/1,000 Gallons	$1.88/1,000 Gallons	$1.76/1,000 Gallons	$0.72/1,000 Gallons
Land availability	---	Vacant property available	Limited availability	County-owned property available	Area available on existing FFWTF site
Capacity Limitations in meeting supply needs	Capacity limited to 4 mgd annual average	None	None	None	Limited to 1 mgd
Existing Public Water Supply Withdrawals	Newport News		• Henrico County • Hopewell • Lynchburg • Richmond	Newport News	
Existing Commercial/Industrial Withdrawals		Yorktown Fossil Power Plant	• James River Correctional Center, Goochland County • Honeywell International, Inc., Hopewell • Dupont E. E. DeNemours & Co., Chesterfield County • Dominion Generation Surry Nuclear Plant • Dominion Generation Chesterfield Power Station • Dominion Generation Bremo Bluff Power Plant, Fluvanna County		
Downstream users that may be impacted		Yorktown Fossil Power Plant	Dominion Generation Surry Nuclear Plant		
Existing VPDES discharges		• Rocktenn CP LLC - West Point • HRSD West Point Sewage Treatment Plant	• BASF Corporation – Williamsburg • Colonial Pipeline Company – Yorktown • Colonial Pipeline Surry • Dominion Yorktown • Grays Creek Marina and Restaurant, Surry • HRSD - Williamsburg Sewage Treatment Plant • JCSA – FFWTF Concentrate Discharge	Hideaway Sewage Treatment Plant – Mount Airy	

Table 12- 1 Evaluation Results of Potential Water Supply Alternatives (continuation)

	Newport News Water Works Purchase Agreement	York River	James River	Chickahominy River	Expansion of FFWTF
Potential Environmental Concerns		• 12-mile section of York River from Almondsville to Plum Point designated as having hydrologic significance in National Park Service, National Rivers Inventory • York River shellfish management area from Clay Bank Wharf to Gloucester Point • Impingement and entrainment of fish eggs and fish larvae • Impact of the concentrate disposal.	• 25-mile segment of James River from 1.2 miles east of Trees Point to Lawnes Creek designated as Scenic River by Virginia DCR • Presence of tidal bald cypress forests and woodlands along James River near Swanns Point, Surry County, listed in DCR Natural Heritage Inventory • Presence of tidal bald cypress forests and woodlands along James River near Swanns Point, Surry County, listed in DCR Natural Heritage Inventory • Impingement and entrainment of fish eggs and fish larvae • Impact of the concentrate disposal.	• 30-mile segment from Providence Forge to James River classified as having botanic and geologic significance in National Park Service, National Rivers Inventory • Presence of fluvial terrace woodlands, Coastal Plain/Piedmont swamp forests, tidal bald cypress forests and woodlands, and tidal freshwater and Oligohaline aquatic beds as identified in DCR Natural Heritage Inventory • Presence of Riverine wetland areas • Impingement and entrainment of fish eggs and fish larvae • Impact of the concentrate disposal.	Impact on declining aquifer levels - riverbank withdrawal wells would be constructed in the same stratum that comprises the surficial water system and would likely be regulated by DEQ under the EVGMA. Water withdrawn from wells would include both river water induced to flow to the well and groundwater. Amount of groundwater withdrawn and impact on aquifer depends on local stratigraphy and natural groundwater flow gradients. Naturally occurring groundwater flow direction would be towards the river with groundwater levels being higher than river levels. If there were a nearby significant existing groundwater withdrawal, natural gradient could be away from the river into the aquifer. It would likely not be possible to design and construct a riverbank withdrawal that would not affect the localized groundwater aquifer. DEQ may also raise concerns regarding the riverbank filtration system inducing saltwater intrusion into the local aquifer system.
Potential Water Quality Concerns		Impact of upstream VPDES discharges	• Presence of kepone (pesticide discharged upstream in 1970s), trapped in bottom sediments of the river. • Impact of VPDES discharges • Potential spill upstream from major highway crossings	• Potential presence of kepone at confluence due to James River tidal influence • Impact of upstream VPDES discharge • Potential spill from automotive bridge crossing and Colonial Petroleum pipeline crossing	• Salt water intrusion • Potential presence of kepone
Permitting/Approval Concerns			• JPA Permit Application approval anticipated to be difficult due to environmental impacts • VDH approval as water supply source may be difficult based on historical opposition due to potential raw water quality impact concerns from existing environmental conditions	Approval of JPA Permit Application may be difficult due to environmental impact concerns	May not be approved if DEQ determines riverbank filtration affects Groundwater Withdrawal Permit



CDM Smith

Figure 12-1
Potential Water Supply Alternatives

For the Chickahominy River alternative, the County has property for the treatment facility. With the James River and York River alternatives, the County will have to purchase property for the treatment facility. Undeveloped property is available adjacent to the York River. Available property close to the James River is highly limited; most of the land in close proximity to the river is developed or protected from development, e.g. historic or park preservation.

From a water distribution standpoint, the York River is located in a more strategic area than the James and Chickahominy River options. The York River supply is located in the northern area of James City County where growth is anticipated.

A summary of the planning-level cost estimates for the proposed surface water supply sources and the O&M cost for an 8-mgd facility is presented in Table 12-2. The James River option appears to be the lowest cost of the surface water supply alternatives, pending the additional costs of the raw water and concentrate discharge mains after a site has been identified.

12.3 Expansion of FFWTF from 5 mgd to 6 mgd

As a short-term alternative, the expansion of the FFWTF from 5 mgd to 6 mgd through riverbank filtration of the James River was considered. Although the primary water source is surface water, there is a degree of uncertainty on how DEQ will relate the riverbank filtration to the groundwater withdrawal permit. This alternative would only be viable as a near-term supply if the permit approval is not delayed and if the riverbank filtration does not affect the permitted groundwater withdrawal. It should be noted that the local soils are not typical for locations where riverbank filtration is used and extensive testing and piloting would be required to determine if this option is feasible and to provide data that will determine the number of wells required and the optimum well field configuration.

12.4 Summary

A summary of the advantages and disadvantages of the water supply alternatives is presented in Table 12-2. Based on the obstacles that have been identified and prior history in its consideration as a water supply source, it is anticipated that permit approval of the James River alternative will be difficult to obtain. It is recommended that JCSA further investigate the Chickahominy River and the York River as a water supply source. Although the costs to develop either of these alternatives are high, they appear to be more promising from a permitting standpoint and will be strategically located where growth is anticipated.

Table 12-2 Planning-Level Cost Estimate Summary for Surface Water Supply Alternatives (Dollars)

Surface Water	4-mgd Capacity	8 mgd Capacity	12 mgd Capacity
		Intake	
Chickahominy River	18,860,000	20,360,000	21,670,000
James River[2]	18,920,000	20,420,000	21,730,000
York River	20,180,000	21,780,000	23,180,000
		Treatment Facility	
Chickahominy River	41,140,000	54,820,000	68,150,000
James River[2]	42,640,000	57,120,000	71,250,000
York River	45,070,000	60,490,000	75,730,000
		Transmission[4]	
Chickahominy River	13,000,000	13,000,000	13,000,000
James River[2]	5,000,000	5,000,000	5,000,000
York River	12,000,000	12,000,000	12,000,000
		Contingencies	
Chickahominy River	18,260,000	22,050,000	25,710,000
James River	16,640,000	20,640,000	24,490,000
York River	19,320,000	23,570,000	27,730,000
		Engineering, Testing, Permitting	
Chickahominy River	14,690,000	17,530,000	20,280,000
James River[3]	15,760,000	18,760,000	21,650,000
York River[3]	16,720,000	19,910,000	23,030,000
		Total Project Cost	
Chickahominy River	105,950,000	127,760,000	148,810,000
James River	98,960,000	121,940,000	144,120,000
York River	113,290,000	137,750,000	161,670,000
		O&M Cost Estimate per 1000 Gallons	
Chickahominy River		$1.76	
James River		$1.88	
York River		$2.00	

Notes:
1. All costs expressed in 2015 Dollars
2. Refine cost for raw water transmission main; concentrate discharge, and finished water transmission main after site has been identified.
3. Includes land acquisition cost.
4. Existing distribution system should be evaluated to determine if the flow will require additional infrastructure improvements.

CDM Smith

Table 12-3 Advantages and Disadvantages of Potential Water Supply Alternatives

Water Supply	Advantages	Disadvantages
NNWW	Agreement in place	• Capacity limitations – inadequate to meet future water demands if DEQ permitted groundwater withdrawal is reduced to 4 mgd • Disinfection compatibility concerns • Cost for 4 mgd share = $33.7 million based on 2nd payment of $25 million subject to inflation; actual cost for JCSA to finance estimated to be $60 million
York River	• Strategically located in area of County where growth is anticipated. • Vacant property available adjacent to proposed intake • Fewer environmental concerns than James River and Chickahominy River that could affect permittability	• Fluctuations in brackish water quality • Potential environmental concerns – impact to hydrologic significance and shellfish management area • Highest anticipated cost for new surface water source ($114M for 4 mgd; $138M for 8 mgd; $162M for 12 mgd)
James River	• Available flow • No extensive finished water transmission main likely since WTF would be located within existing system if property is available, but costs may be offset by likely transmission upgrades required to deliver water to the northern growth area	• Limited availability of vacant property in the vicinity of the river • Fluctuations in brackish water quality • Potential environmental concerns, impact to Historic, Scenic River, tidal bald cypress forests and woodlands • Impact of potential presence of kepone in bottom sediments of the river on water quality • Potential negative public perception of VDPES discharges in close proximity to intake • Difficulty in obtaining JPA permit application and VDH approval • High costs ($99M for 4 mgd; $122M for 8 mgd; $144M for 12 mgd)
Chickahominy River	County-owned property available	• Fluctuations in brackish water quality if intake located downstream of Walker's Dam • Potential flow limitations during drought conditions • Potential presence of kepone due to tidal influence of James River • High costs ($106M for 4 mgd; $128M for 8 mgd; $149M for 12 mgd)
Expansion of FFWTF from 5- to 6-mgd with riverbank filtration		• Uncertainty in how riverbank filtration will be addressed by DEQ in the groundwater withdrawal permit resulting in potential difficulty in obtaining DEQ approval • Local soils are not typical for locations where riverbank filtration is used and extensive testing and piloting would be required to determine if this option is feasible • Additional plant staff will be required due to higher capacity • Potential presence of kepone • Short-term solution

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APPENDIX A

Appendix A EPA and VDEQ Water Monitoring Stations on James River - Available Data (2005-2014)

Station ID		21VASWCB-2-JMS042.92[a]				EMAP_CS_WQX-VA05-0047-A[b]				21VASWCB-J-JMS032.59[c]			
Parameter	Units	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	ng/g					0.5	0.5	0.5	1				
2,2',3,3',4,4',5,6-Octachlorobiphenyl	ng/g					0	0	0	1				
2,2',3,3',4,4',5-Heptachlorobiphenyl	ng/g					1.1	1.1	1.1	1				
2,2',3,3',4,4'-Hexachlorobiphenyl	ng/g					0	0	0	1				
2,2',3,4,4',5,5'-Heptachlorobiphenyl	ng/g					2	2	2	1				
2,2',3,4,4',5'-Hexachlorobiphenyl	ng/g					2.3	2.3	2.3	1				
2,2',3,4',5,5',6-Heptachlorobiphenyl	ng/g					1.5	1.5	1.5	1				
2,2',3,5'-Tetrachlorobiphenyl	ng/g					1.3	1.3	1.3	1				
2,2',4,4',5,5'-Hexachlorobiphenyl	ng/g					3.4	3.4	3.4	1				
2,2',4,5,5'-Pentachlorobiphenyl	ng/g					3.8	3.8	3.8	1				
2,2',5,5'-Tetrachlorobiphenyl	ng/g					1.8	1.8	1.8	1				
2,2',5-Trichlorobiphenyl	ng/g					0.76	0.76	0.76	1				
2,3,3',4,4'-Pentachlorobiphenyl	ng/g					0	0	0	1				
2,3',4,4',5-Pentachlorobiphenyl	ng/g					0	0	0	1				
2,3',4,4'-Tetrachlorobiphenyl	ng/g					2.3	2.3	2.3	1				
2,4,4'-Trichlorobiphenyl	ng/g					1.3	1.3	1.3	1				
2,4'-Dichlorobiphenyl	ng/g					0	0	0	1				
3,3',4,4',5-Pentachlorobiphenyl	ng/g					1.3	1.3	1.3	1				
3,3',4,4'-Tetrachlorobiphenyl	ng/g					0.97	0.97	0.97	1				
Aluminum	ug/g					65700	65700	65700	1				
Ammonia	mg/l					0.008	0.033	0.018333	3				
Ammonia as N	mg/l	0.004	0.066	0.032273	11					0.009	0.05	0.025875	8
Antimony	ug/g					1.3	1.3	1.3	1				
Arsenic	ug/g					12.6	12.6	12.6	1				
Cadmium	ug/g					1.7	1.7	1.7	1				
Carbon	mg/l	0.096	15.307	4.085267	15					0.408	3.2	1.2685	8
Chlorophyll a	ug/l					5.77	6.3	6.016667	3				
Chlorophyll a, corrected for pheophytin	ug/l	4.15	4.24	4.195	2					2.53	4.04	3.285	2
Chlorophyll a, uncorrected for pheophytin	ug/l	5.59	6.15	5.87	2					3.26	4.75	4.005	2
Chlorophyll b	ug/l	0.1	0.11	0.105	2					0.1	0.1	0.1	2
Chlorophyll c	ug/l	0.33	0.41	0.37	2					0.12	0.5	0.31	2
Chromium	ug/g					75.5	75.5	75.5	1				
Copper	ug/g					48.7	48.7	48.7	1				
Decachlorobiphenyl	ng/g					2.2	2.2	2.2	1				
Depth, Secchi disk depth	m	0.5	0.7	0.6	3	0.6	0.6	0.6	1	0.5	1.1	0.833333	3
Dieldrin	ng/g					3.4	3.4	3.4	1				
Dissolved oxygen (DO)	mg/l	11.6	11.84	11.69	5	5.54	6.42	5.98	2	10.1	10.64	10.376	5
Enterococcus	cfu/100ml	25	25	25	5					25	25	25	4
Fecal Coliform	cfu/100ml	25	25	25	5					25	25	25	4
Fixed suspended solids	mg/l	3	126	44.63636	11					6	122	32.625	8
Heptachlor epoxide	ng/g					3	3	3	1				
Hexachlorobenzene	ng/g					0	0	0	1				
Inorganic nitrogen (nitrate and nitrite)	mg/l					0.12	0.122	0.121	3				
Inorganic nitrogen (nitrate and nitrite) as N	mg/l	0.004	0.429	0.295909	11					0.198	0.425	0.289625	8
Iron	ug/g					55600	55600	55600	1				
Lead	ug/g					69.9	69.9	69.9	1				
Lindane	ng/g					0	0	0	1				
Manganese	ug/g					1130	1130	1130	1				
Mercury	ug/g					0.26	0.26	0.26	1				
Nickel	ug/g					35.9	35.9	35.9	1				
Nitrate	mg/l					0.074	0.076	0.075	3				
Nitrate as N	mg/l	0.004	0.425	0.292273	11					0.197	0.421	0.285	8
Nitrite	mg/l					0.046	0.046	0.046	2				
Nitrite as N	mg/l	0.002	0.006	0.003909	11					0.002	0.01	0.00475	8
Nitrogen	mg/l					0.541	0.718	0.636	3				
Nitrogen as N	mg/l	0.01	3	0.626	26					0.062	0.613	0.347313	16
o,p'-DDE	ng/g					3	3	3	1				
o,p'-DDT	ng/g					0	0	0	1				
Organic carbon	%					2.139	2.139	2.139	1				
Orthophosphate	mg/l					0.023	0.024	0.0235	2				
p,p'-DDD	ng/g					17	17	17	1				
p,p'-DDE	ng/g					11	11	11	1				
p,p'-DDT	ng/g					0	0	0	1				
PCB-77/110	ng/g					2.6	2.6	2.6	1				
pH	None	7.68	8.63	7.902	25	7.2	7.37	7.285	2	7.7	7.95	7.8172	25
Pheophytin a	ug/l	2.13	2.85	2.49	2					0.91	1.04	0.975	2
Pheophytin ratio	%	1.418	1.462	1.44	2					1.496	1.572	1.534	2
Phosphorus	mg/l					0.0771	0.1382	0.105967	3				
Phosphorus as P	mg/l	0.003	0.4325	0.059596	26					0.005	0.039	0.02175	16
Phosphorus, Particulate Organic as P	mg/l	0.0029	0.1608	0.074455	11					0.014	0.1268	0.05145	8
Salinity	ppth	0.04	5.67	3.8668	25	3.6	3.7	3.65	2	0.48	10.38	7.3892	25
Silica	mg/l	0.1	6.9	4.609091	11					6	6.8	6.425	4
Silver	ug/g					0.7	0.7	0.7	1				
Specific conductance	umho/cm	106	10000	6929.56	25					922	17538	12728.32	25
Substrate - sand, coarse	%					5	5	5	1				
Substrate - silt/clay mix	%					95	95	95	1				
Temperature, water	deg C	8.35	15.51	12.3752	25	29.87	30.39	30.13	2	8.49	15.76	12.4872	25
Tin	ug/g					7.1	7.1	7.1	1				
Total suspended solids	mg/l	3	144	51.72727	11	32	118	63	3	8	142	38.875	8
Total volatile solids	mg/l	3	18	7.454545	11					2	20	6.25	8
Turbidity	NTU	0.95	80.2	37.91364	11					6.63	88.6	25.845	8
Zinc	ug/g					317	317	317	1				

source: http://watersgeo.epa.gov/mwm/

APPENDIX B

Table B-1 Water Quality Data for NNWW Chickahominy River Monitoring Station CR-1 (May 1, 1991 – October 13, 2014)

Parameter	Unit	Minimum	Maximum	Average
Blue-Green Algae-Hydrolab	ug/L	0.00	7.30	0.08
Chlorophyll A	mg/M3	0.35	25.60	7.52
Chlorophyll a –Hydrolab	ug/L	0.20	111.40	14.87
Color	Std Units	2.00	140.00	55.32
Specific Conductance	uS/CM as 25C	0.00	2.76	0.14
Copper, Dissolved	ug/L Cu	9.60	9.60	9.60
Oxygen, Dissolved	mg/L DO	0.00	13.65	8.02
DOC	mg/L as C	7.70	12.07	9.41
Absorbance 254 (Filtered)	CM -1	0.16	0.46	0.32
Absorbance 280 (Filtered)	CM -1	0.11	0.34	0.24
Hydrophilic Acid	mg/L as C	1.50	5.10	2.62
Hydrophilic Bases	mg/L as C	0.10	1.00	0.49
Hydrophobic Acid	mg/L as C	1.70	5.80	3.53
Hydrophobic Bases	mg/L as C	0.00	0.80	0.37
Neutrals	mg/L as C	0.00	1.50	0.73
pH, WH, Field	Std Units	1.46	10.73	7.13
Visibility	ft	1.60	7.00	3.89
Alkalinity, Total	mg/L as CaCO3	2.00	32.00	15.12
Ammonia, Total	mg/L as N	0.00	4.71	0.04
Bromide, Total	mg/L as Br	0.02	0.20	0.07
Calcium, Total	mg/L as Ca	2.56	30.80	7.54
Chloride, Total	mg/L as Cl	1.00	24.00	13.41
Copper, Total	ug/L Cu	1.00	146.00	23.30
HAAFP, Total	ug/L HAA	234.00	1511.00	693.36
Hardness, Total	mg/L as CaCO3	5.00	78.00	35.50
Iron, Total	ug/L as Fe	0.78	3906.00	1001.95
Magnesium, Total	mg/L as Mg	0.87	43.00	2.41
Manganese, Total	ug/L as Mn	18.00	1432.55	113.48
Nitrate, Total	mg/L as N	0.00	2.20	0.05
Nitrite, Total	mg/L as N	0.00	0.02	0.00
Orthophosphate, Total	mg/L as P	0.00	0.13	0.02
Phosphorus, Total	mg/L as P	0.01	0.56	0.06
Potassium, Total	mg/L as K	0.04	20.70	2.30
Silica, Total	mg/L SiO2	1.55	8.43	5.12
Sodium, Total	mg/L as Na	2.30	389.20	14.71
Sulfate, Total	mg/L as SO4	0.00	15.30	5.11
THMFP, Total	ug/L THM	6.00	2754.00	550.47
TKN, Total	mg/L as N	0.04	2.45	0.58
TOC, Total	mg/L	3.51	17.96	8.74
TOC < 10K Daltons	mg/L as C	4.60	8.36	6.05
TOC < 1K Daltons	mg/L as C	1.40	5.16	2.97
TOC < 3K Daltons	mg/L as C	2.50	6.05	4.39
TOXFP	ug/L TOX	1126.00	3334.00	1939.29
Absorbance 254 (Unfiltered)	CM -1	0.11	4.52	0.78
Absorbance 280 (Unfiltered)	CM -1	0.17	0.32	0.24
Water Temperature	Degrees Celsius	1.10	32.70	17.02

Note: Values provided by NNWW

Table B-2 EPA and DEQ Water Monitoring Stations on Chickahominy River

Station ID		2-CHK023.64				VA05-0001-A				2-CHK006.14			
Parameter	Units	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples
2,2',3,4,4',5,5'-Heptachlorobiphenyl	ng/g					0.38	0.38	0.38	1				
2,2',3,4,4',5'-Hexachlorobiphenyl	ng/g					0.8	0.8	0.8	1				
2,2',3,4',5,5',6-Heptachlorobiphenyl	ng/g					0	0	0	1				
2,2',3,5'-Tetrachlorobiphenyl	ng/g					0.52	0.52	0.52	1				
2,2',4,4',5,5'-Hexachlorobiphenyl	ng/g					0.78	0.78	0.78	1				
2,2',4,5,5'-Pentachlorobiphenyl	ng/g					3.9	3.9	3.9	1				
2,2',5,5'-Tetrachlorobiphenyl	ng/g					0	0	0	1				
2,2',5-Trichlorobiphenyl	ng/g					0.55	0.55	0.55	1				
Aluminum	ug/g					28000	28000	28000	1				
Ammonia	mg/l					0.015	0.015	0.015	1				
Ammonia as N	mg/l									0.008	0.056	0.026375	8
Ammonium as NH4	mg/l												
Anthracene	ng/g												
Antimony	ug/g					0.4	0.4	0.4	1				
Arsenic	ug/g					6.7	6.7	6.7	1				
Benz[a]anthracene	ng/g					11	11	11	1				
Benzo(b)fluoranthene	ng/g					13	13	13	1				
Benzo[a]pyrene	ng/g												
Benzo[ghi]perylene	ng/g												
Benzo[k]fluoranthene	ng/g												
Biphenyl	ng/g												
Cadmium	ug/g					0.55	0.55	0.55	1				
Carbon	mg/l									0.5	3.63	1.7576	10
Chlorophyll a	ug/l					6.942	6.942	6.942	1				
Chlorophyll a, corrected for pheophytin	ug/l									11.6	12.9	12.25	2
Chlorophyll b	ug/l									0.1	0.1	0.1	2
Chlorophyll c	ug/l									1.48	1.99	1.735	2
Chromium	ug/g					35.1	35.1	35.1	1				
Chrysene	ng/g					12	12	12	1				
Copper	ug/g					30	30	30	1				
Depth, Secchi disk depth	m					0.3	0.3	0.3	1	0.3	0.8	0.5	3
Dibenz[a,h]anthracene	ng/g												
Dibenzothiophene	ng/g												
Dieldrin	ng/g												
Dissolved oxygen (DO)	mg/l	8.56	9.54	9.05	2	9.34	9.34	9.34	1	9.38	11.67	10.50917	12
Endosulfan	ng/g												
Enterococcus	cfu/100ml									25	25	25	2
Escherichia coli	cfu/100ml	25	25	25	1					25	25	25	2
Fecal Coliform	cfu/100ml	25	25	25	1					25	50	31.25	4
Fixed suspended solids	mg/l									3	72	21.6	10
Fluoranthene	ng/g					18	18	18	1				
Fluorene	ng/g												
Hardness, Ca, Mg	mg/l	31.1	31.1	31.1	1					33.9	52	42.95	2
Indeno[1,2,3-cd]pyrene	ng/g												
Inorganic nitrogen (nitrate and nitrite)	mg/l					0.003	0.003	0.003	1				
Inorganic nitrogen (nitrate and nitrite) as N	mg/l									0.06	0.299	0.169375	8
Iron	ug/g					27000	27000	27000	1				
Kjeldahl nitrogen as N	mg/l	0.5	0.5	0.5	1								
Lead	ug/g					18.8	18.8	18.8	1				
Lindane	ng/g					0	0	0	1				
Manganese	ug/g					439	439	439	1				
Mercury	ug/g					0.054	0.054	0.054	1				
Naphthalene	ng/g												
Nickel	ug/g					15.4	15.4	15.4	1				
Nitrate	mg/l												
Nitrate as N	mg/l									0.058	0.295	0.167	8
Nitrite	mg/l												
Nitrite as N	mg/l									0.002	0.004	0.0025	8
Nitrogen	mg/l					4.6179	4.6179	4.6179	1				
Nitrogen as N	mg/l	0.5	0.6	0.55	2					0.185	0.49	0.337667	18
Organic carbon	%					6.763	6.763	6.763	1				
Orthophosphate	mg/l					0.016	0.016	0.016	1				
Orthophosphate as PO4	mg/l												
p,p'-DDD	ng/g												
p,p'-DDE	ng/g												
p,p'-DDT	ng/g												
PCB-77/110	ng/g					0.97	0.97	0.97	1				
pH	None	6.36	7.36	6.86	2	8.8	8.8	8.8	1	7.53	8.01	7.673333	12
Phenanthrene	ng/g												
Pheophytin a	ug/l									7.31	8.56	7.935	2
Pheophytin ratio	%									1.421	1.429	1.425	2
Phosphorus	mg/l					0.1081	0.1081	0.1081	1				
Phosphorus as P	mg/l	0.06	0.06	0.06	2					0.005	0.019	0.009688	16
Phosphorus, Particulate Organic as P	mg/l									0.0162	0.0715	0.04575	10
Pyrene	ng/g					26	26	26	1				
Salinity	ppth	0	0	0	1	0.34	0.34	0.34	1	0	2.2	1.45	12
Selenium	ug/g												
Silica	mg/l									4.2	6	5.075	4
Silver	ug/g					0.1	0.1	0.1	1				
Specific conductance	umho/cm	109	118	113.5	2					136	4041	2356.857	14
Substrate - sand, coarse	%					46	46	46	1				
Substrate - silt/clay mix	%					54	54	54	1				
Temperature, water	deg C	7.2	17.5	12.35	2	28.8	28.8	28.8	1	7.6	15.66	12.48083	12
Tin	ug/g					3.7	3.7	3.7	1				
Total fixed solids	mg/l									83	103	93	2
Total solids	mg/l	89	95	92	2					103	122	112.5	2
Total suspended solids	mg/l	5	5	5	2	43.8	43.8	43.8	1	3	86	26.6	10
Total volatile solids	mg/l									3	20	7.833333	12
Toxicity sediment survival	%												
Trimethylnaphthalene	ng/g												
Turbidity	NTU	3.9	5.07	4.485	2					0.12	54.4	18.136	10
Zinc	ug/g					78.8	78.8	78.8	1				

Source: Environmental Protection Agency. 2014. STORET (http://watersgeo.epa.gov/mwm/)

Table B-2 EPA and DEQ Water Monitoring Stations on Chickahominy River (continuation)

Station ID		VA06-0081-A				VA02-0022				2-CHK002.17			
Parameter	Units	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples	Min	Max	Avg	No. of Samples
2,2',3,4,4',5,5'-Heptachlorobiphenyl	ng/g					0.29	0.29	0.29	1				
2,2',3,4,4',5'-Hexachlorobiphenyl	ng/g					0.26	0.26	0.26	1				
2,2',3,4',5,5',6-Heptachlorobiphenyl	ng/g					0.15	0.15	0.15	1				
2,2',3,5'-Tetrachlorobiphenyl	ng/g					0	0	0	1				
2,2',4,4',5,5'-Hexachlorobiphenyl	ng/g					0.52	0.52	0.52	1				
2,2',4,5,5'-Pentachlorobiphenyl	ng/g					0.32	0.32	0.32	1				
2,2',5,5'-Tetrachlorobiphenyl	ng/g												
2,2',5-Trichlorobiphenyl	ng/g												
Aluminum	ug/g	50500	50500	50500	1	22300	22300	22300	1				
Ammonia	mg/l	0	0.007	0.004333	3								
Ammonia as N	mg/l												
Ammonium as NH4	mg/l					0	0.004	0.002667	3				
Anthracene	ng/g	10.9	10.9	10.9	1								
Antimony	ug/g	0.981	0.981	0.981	1	0.59	0.59	0.59	1				
Arsenic	ug/g	9	9	9	1	2.9	2.9	2.9	1				
Benz[a]anthracene	ng/g	28.5	28.5	28.5	1								
Benzo(b)fluoranthene	ng/g	31.4	31.4	31.4	1								
Benzo[a]pyrene	ng/g	35.1	35.1	35.1	1								
Benzo[ghi]perylene	ng/g	19.5	19.5	19.5	1								
Benzo[k]fluoranthene	ng/g	36.8	36.8	36.8	1								
Biphenyl	ng/g	4.4	4.4	4.4	1								
Cadmium	ug/g	0.331	0.331	0.331	1	0.73	0.73	0.73	1				
Carbon	mg/l												
Chlorophyll a	ug/l	18.156	25.632	21.538	3	10.25	10.7	10.47333	3				
Chlorophyll a, corrected for pheophytin	ug/l												
Chlorophyll b	ug/l												
Chlorophyll c	ug/l												
Chromium	ug/g	65.6	65.6	65.6	1	20	20	20	1				
Chrysene	ng/g	32.3	32.3	32.3	1	0	0	0	1				
Copper	ug/g	24.4	24.4	24.4	1	9.9	9.9	9.9	1				
Depth, Secchi disk depth	m	0.5	0.5	0.5	1								
Dibenz[a,h]anthracene	ng/g	6.3	6.3	6.3	1								
Dibenzothiophene	ng/g	3.6	3.6	3.6	1								
Dieldrin	ng/g	0	0	0	1								
Dissolved oxygen (DO)	mg/l	7.9	8.4	8.15	2					9.9	12.4	11.15	2
Endosulfan	ng/g												
Enterococcus	cfu/100ml									25	25	25	1
Escherichia coli	cfu/100ml												
Fecal Coliform	cfu/100ml									25	25	25	1
Fixed suspended solids	mg/l												
Fluoranthene	ng/g	61	61	61	1	16	16	16	1				
Fluorene	ng/g	6.7	6.7	6.7	1								
Hardness, Ca, Mg	mg/l									43.8	43.8	43.8	1
Indeno[1,2,3-cd]pyrene	ng/g	24.7	24.7	24.7	1								
Inorganic nitrogen (nitrate and nitrite)	mg/l	0	0.007	0.004333	3								
Inorganic nitrogen (nitrate and nitrite) as N	mg/l												
Iron	ug/g	43000	43000	43000	1	16100	16100	16100	1				
Kjeldahl nitrogen as N	mg/l									0.9	0.9	0.9	1
Lead	ug/g	26.3	26.3	26.3	1	17.9	17.9	17.9	1				
Lindane	ng/g	0	0	0	1	0	0	0	1				
Manganese	ug/g	1350	1350	1350	1	522	522	522	1				
Mercury	ug/g	0.1	0.1	0.1	1	0.041	0.041	0.041	1				
Naphthalene	ng/g	5.8	5.8	5.8	1								
Nickel	ug/g	31.2	31.2	31.2	1	8.4	8.4	8.4	1				
Nitrate	mg/l	0.002	0.005	0.003667	3								
Nitrate as N	mg/l												
Nitrite	mg/l	0.002	0.002	0.002	2								
Nitrite as N	mg/l												
Nitrogen	mg/l	2.357	3.383	2.737667	3								
Nitrogen as N	mg/l									0.58	0.72	0.65	2
Organic carbon	%	2.763	2.763	2.763	1	0.81	0.81	0.81	1				
Orthophosphate	mg/l	0.012	0.014	0.013	3								
Orthophosphate as PO4	mg/l					0.017	0.018	0.017667	3				
p,p'-DDD	ng/g	0	0	0	1	0	0	0	1				
p,p'-DDE	ng/g	1.4	1.4	1.4	1	0.48	0.48	0.48	1				
p,p'-DDT	ng/g	10	10	10	1								
PCB-77/110	ng/g												
pH	None	7.8	7.9	7.85	2					7.4	7.9	7.65	2
Phenanthrene	ng/g					10	10	10	1				
Pheophytin a	ug/l												
Pheophytin ratio	%												
Phosphorus	mg/l	0.071	0.097	0.082333	3								
Phosphorus as P	mg/l									0.06	0.09	0.075	2
Phosphorus, Particulate Organic as P	mg/l												
Pyrene	ng/g	48.9	48.9	48.9	1	15	15	15	1				
Salinity	ppth	1.8	1.8	1.8	1					0	1.09	0.545	2
Selenium	ug/g	0.719	0.719	0.719	1	0.65	0.65	0.65	1				
Silica	mg/l												
Silver	ug/g	0.379	0.379	0.379	1	0.12	0.12	0.12	1				
Specific conductance	umho/cm									129	2064	1096.5	2
Substrate - sand, coarse	%	15	15	15	1								
Substrate - silt/clay mix	%	85	85	85	1	27.47	27.47	27.47	1				
Temperature, water	deg C	30.3	30.4	30.35	2					8.08	17	12.54	2
Tin	ug/g	3.19	3.19	3.19	1	4.4	4.4	4.4	1				
Total fixed solids	mg/l												
Total solids	mg/l									113	1230	671.5	2
Total suspended solids	mg/l	29.6	48.1	37.83333	3					20	27	23.5	2
Total volatile solids	mg/l												
Toxicity sediment survival	%					97.8	97.8	97.8	1				
Trimethylnaphthalene	ng/g	4.2	4.2	4.2	1								
Turbidity	NTU												
Zinc	ug/g	124	124	124	1	48.4	48.4	48.4	1				

Source: Environmental Protection Agency. 2014. STORET (http cdmsmith.com